APPENDIX H

DESIGN EXAMPLE - ACTIVE CHANNEL DESIGN OPTION

Active Channel Design
(Culvert Replacement)

Problem Statement

Within the City limits of Folsom in Sacramento County, Route 888 has been plagued with head-on/cross-over collisions, and has poor level of service due to highway capacity issues. In order to improve level of service and reduce traffic accidents, a 5-mile stretch of Route 888 will be widened from two to four lanes and separated by a median barrier. Due to the widening of the highway, existing culverts must be lengthened or replaced depending on field and hydraulic conditions.

One of the existing culverts that must be addressed in the design process is at Blue Creek. The existing culvert diameter is 48 inches and is 30 feet in length. Over time, the corrugated metal pipe has abraded from transported sand cobble bed load to a point where most of the culvert bottom is missing.

Blue Creek supports various native non-salmonids and non-native fish species in its corridor, therefore fish passage must be considered as an aspect of design. Given the poor structural condition of the existing culvert and this need to provide fish passage, the culvert should be replaced instead of attempting to rehabilitate it through various culvert liners or baffles.

NOTE: Route 888 and Blue Creek are fictitious and created for the purpose of presenting a design example for this fish-passage training guidance.

Form 1 - Existing Data and Information Summary

Form 1 provides a list of suggested data references that would be beneficial to collect before the beginning of design process.

For this particular example, an assessor's parcel map, USGS topographic quadrangle map, hydrology analysis, hydraulics analysis, floodplain mapping from an effective FEMA flood insurance study, and a proposed land use map was available for reference. As for site access, the field investigations cannot be done within Caltrans right-of-way; therefore, right-of-entry will be required.

The USGS topographic quadrangle data was downloaded from the USGS website, www.usgs.gov.

The FEMA Map Service Center, http://msc.fema.gov/, was accessed to determine if a previous hydrologic study, hydraulic study, and/or floodplain mapping had been performed. For Blue Creek, an effective detailed study had been conducted. Floodplain mapping, water surface elevation profiles, and floodway data table were created because of the study.

The City's engineering department was able to provide a proposed land use and assessors parcel map for the project study area. The proposed land use map provided 2015 land use conditions.

California Department of Water Resources (CDEC, http://cdec.water.ca.gov/), was searched for precipitation and stream flow gage data. Unfortunately, no stream flow gages were located on Blue Creek or precipitation gages located in close vicinity.

EXISTING DATA AND INFORMATION SUMMARY — FORM 1

Project Information		Computed: EKB	Date: 5/1/06
Route 888 4-Lane		Checked: JJL	Date: 5/2/06
Stream Name: Blue Creek	County: Sacramento	Route: 888	Postmile: 67.2

Proposed Project Type		
	☐ New Culvert	☐ New Bridge
	☒ Replacement Culvert	☐ Replacement Bridge
	☐ Retrofit Culvert	☐ Retrofit Bridge
	☐ Proposed Culvert Length= 68.0 ft	☐ Proposed Bridge Length= ft
	☐ Other	☐ Other

Design Species/Life Stage		Source: Contact: Date:
	☒ All Species	St. of CA Dept. of Fish & Game Bill Hook 916-361-9322
	☐ Adult Anadromous Salmonids	
	☐ Adult Non-Anadromous Salmonids	
	☐ Juvenile Salmonids	
	☐ Native Non-Salmonids	
	☐ Non-Native Species	

Collect Existing Data

	Yes	No
Included in Caltrans Culvert Inventory	☐	☒
As-Built Drawings	☐	☒
Assessor's Parcel Map	☒	☐
Previous Studies Performed: (i.e. FEMA Flood Insurance Studies, Army Corps of Engineering Studies, Other)		
Hydrology Analysis	☒	☐
Hydraulics Analysis	☒	☐
Floodplain Mapping	☒	☐
Other Studies Types Available: (i.e. Watershed Management Plans, Stream Restoration Plans, Other)	☐	☒
Existing Land Use Map	☐	☒
Proposed Land Use Map	☒	☐
Precipitation Gage Data	☐	☒
Stream Flow Gage Data	☐	☒

EXISTING DATA AND INFORMATION SUMMARY	FORM 1
Topographic Mapping: (i.e USGS Topographic Quadrangle, DEM Data, LIDAR Data, Other)	☒ Yes ☐ No
District Hydraulics Library	☐ Yes ☒ No

Obtain Access Permission

Will Project study limits extend beyond Caltrans R/W? ☒ Yes ☐ No

If yes, obtain right-of-entry.

Contact Report Index Attached ☒ Yes ☐ No

Existing Information Index Attached ☒ Yes ☐ No

CONTACT REPORT INDEX

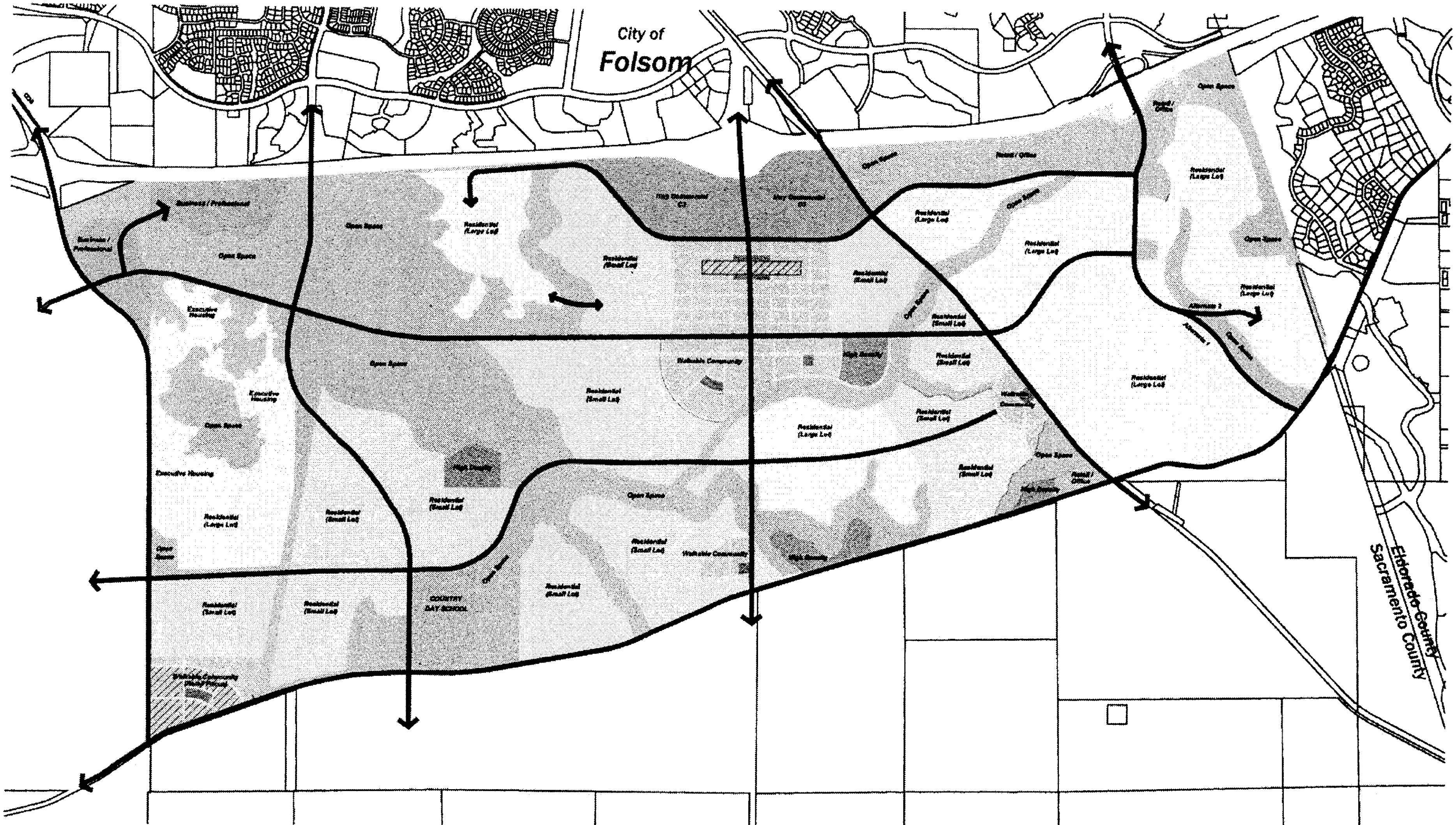
Project Information	Computed: EKB	Date: 5/1/06
Route 888 4-lane	Checked: JJL	Date: 5/2/06
Stream Name: Blue Creek / County: Sacramento	Route: 888	Postmile: 67.2

Date of Contact	Person Contacted	Subject Discussed
4/16/06	Joe Brown, City of Folsom	Requested historical
	916-983-1010	flow data
4/22/06	Bill Hook, St. of CA	Requested design
	Dept. of Fish + Game	species information
	916-361-9322	

EXISTING INFORMATION INDEX

Project Information	Computed: EKB	Date: 5/1/06
Route 888 4-lane	Checked: JJL	Date: 5/2/06
Stream Name: Blue Creek / County: Sacramento	Route: 888	Postmile: 67.2

Report Date	Report Name and Source
5/05	Proposed Annexation Concept Plan
	City of Folsom Sphere of Influence
9/30/92	FEMA - FIS Study - City of Folsom, CA
	Sacramento County
4/25/06	California Dept of Water Resources (CDEC)
	CDEC Station Locator
2004	County of Sacramento, Department of
	Water Resources - LIDAR



Legend

- Proposed Minor Roadways
- Proposed Arterial / Collector
- Business / Professional
- Retail / Office
- Highway Commercial
- Open Space
- School
- Residential (Small Lot)
- Residential (Large Lot)
- Executive Housing
- High Density Residential
- Walkable Community
- Walkable Community - Mixed
- Public - Quasi Public

Folsom Sphere of Influence Area Land Use Summary

	Acres	Density	Range of Product	Total Dwelling Units
Executive Housing	110	3 du/ac	2-4 du/ac	330
Large Lot	590	4-5	2-6	2360 - 2950
Small Lot	900	6-9	6-12	5400 - 8100
High Density	50	20	18-22	1000
Walkable Community	150	15	13-22	2250
Total Residential	**1800**			**11340 - 14630**
Highway Commercial	100			
Business / Professional	70			
Retail / Office	125			
Public / Quasi Public	10			
School / Park	297			
Open Space	1076			
Major Roads	107			
Total	**3584**			

Note: School and park site locations and exact land use categories to be determined during the precise planning stage.

Proposed Annexation Concept Plan

City of Folsom Sphere of Influence

Sacramento County, California

CDEC Station Locator - Stations near AMERICAN R AT FOLSOM *(AMF)*

AMERICAN R AT FOLSOM *(AMF)* is located at latitude 38.683, longitude -121.183.

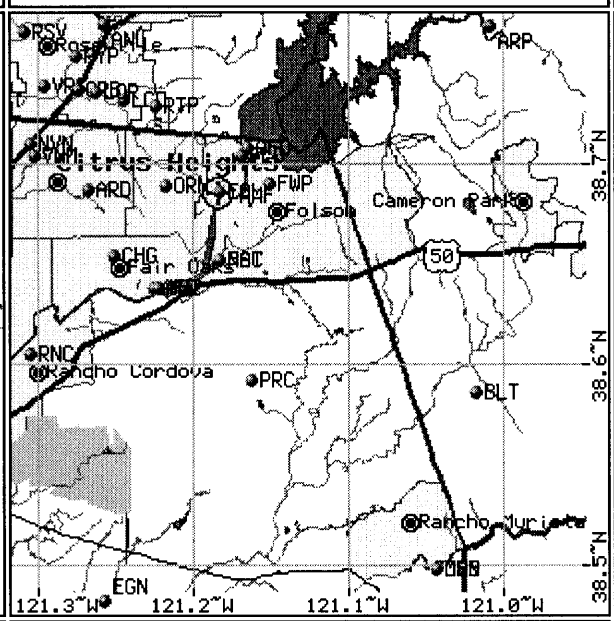
Map Level

Get All Stations

Search

NW | NORTH | NE

WEST



EAST

SW | SOUTH | SE

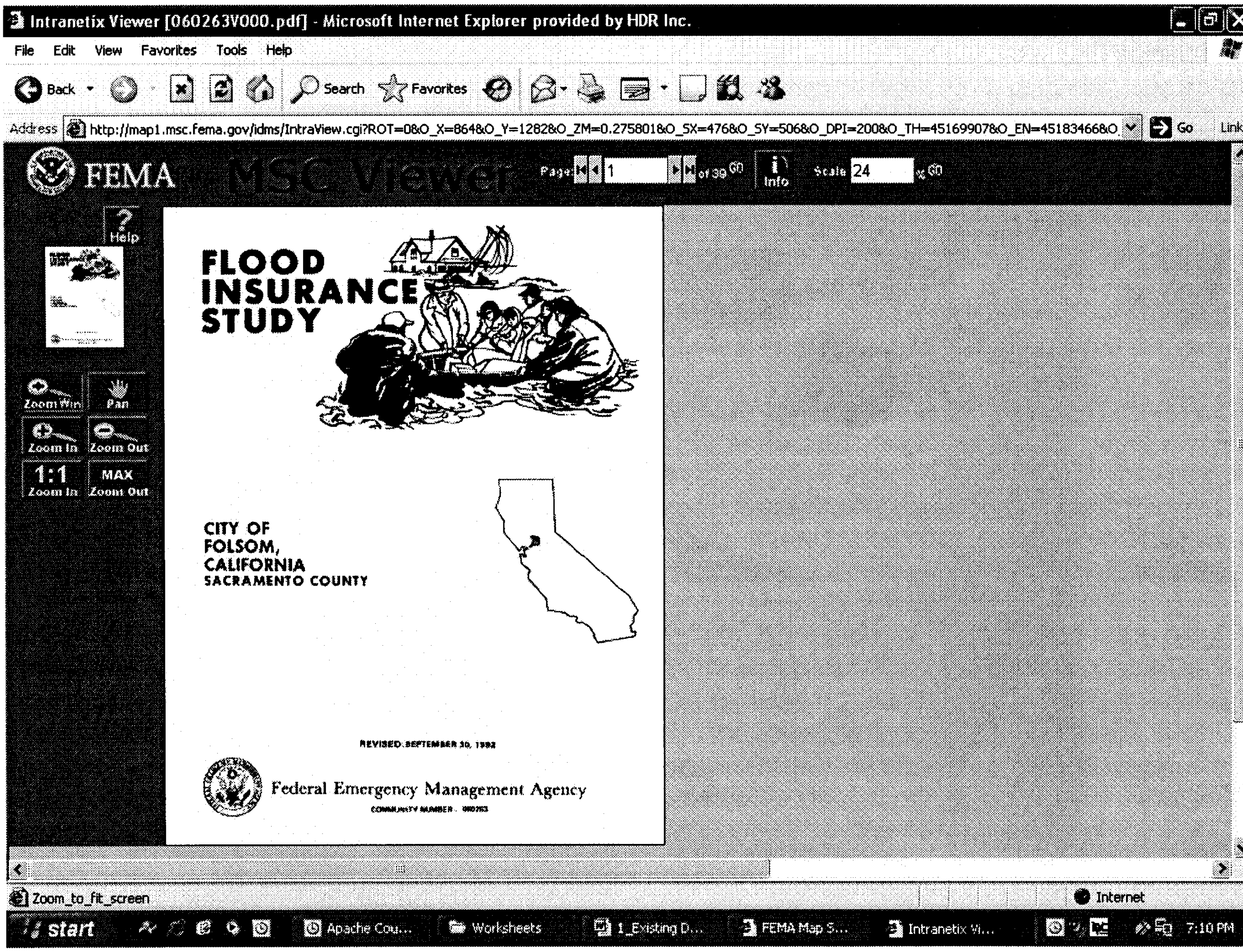
Click On Dot For Station Information Or Select Sensor

Scale 1:328424 0 2 4 6 8 10 mi 0 5 10 15 20 km
*average--true scale depends on monitor resolution

Station:

All stations in the area:

AFD - AMERICAN R BELOW FOLSOM DAM
AFO - AMERICAN RIVER AT FAIR OAKS
AHZ - AMERICAN R AT HAZEL AVE BRIDGE
AMF - AMERICAN R AT FOLSOM
ANL - ANTELOPE CREEK AT LANDFILL
ARD - ARCADE CREEK AT SUNRISE BLVD
ARP - SO FRK AMERICAN R NR PILOT HILL
BLT - BEN BOLT
CHG - CHICAGO
CRB - CIRBY CREEK - TINA WAY
CSN - COSUMNES R AT MICHIGAN BAR
EGN - COSUMNES RIVER AT EAGLES NEST ROAD
FLD - FOLSOM DAM
FOL - FOLSOM LAKE
FSC - FOLSOM SOUTH CANAL
FWP - FOLSOM WATER TREATMENT PLANT
LCO - LINDA CREEK AT CHAMPION OAKS
LOR - LINDA CREEK AT OAK RIDGE ROAD
MHB - COSUMNES RIVER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FLOOD INSURANCE STUDY
CITY OF FOLSOM, CALIFORNIA
SACRAMENTO COUNTY
REVISED: SEPTEMBER 30, 1992
Federal Emergency Management Agency
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Form 2 - Site Visit Summary

Form 2 captures the existing conditions of the hydraulic structure including channel and structure roughness values. By completing the Site Visit Summary form, the drainage designer will have all necessary parameters required to complete any of the fish passage design options.

For this particular example, the corrugated metal pipe culvert is slightly projecting from the surrounding fill on both the inlet and outlet. The existing culvert slope matched the surrounding channel invert slope of 0.5%.

Manning's n-values were calculated for the channel and left and right overbanks. For this project site, the left and right overbanks displayed the similar roughness characteristics; therefore, the same Manning's n-value was used for both the left and right overbanks.

The active channel width was measured by looking for the active channel stage or ordinary high water level, which is the elevation delineating the highest water level that has been maintained for a sufficient period to leave evidence on the landscape. Evidence shown included bank elevation at which cleanly scoured substrate of the stream ends and terrestrial vegetation began, a break in rooted vegetation or moss growth on rocks along stream margins, natural line impressed on the bank, shelving or terracing, changes in soil character, presence of deposited organic debris and litter, natural vegetation changes from predominantly aquatic to predominantly terrestrial. Five channel width measurements were measured and averaged to determine the active channel width. The best measurement sites are located above the crossing in a channel reach visually beyond any influence the crossing may have on channel width. If it had not been possible to measure active channel width above the crossing, downstream measurements could have been taken beyond the influence of the crossing. An average of these measurements should account for natural variations in channel width.

In addition, flow in the creek at the time of the field visit was determined from appropriate measurements. The flow was calculated by measuring a velocity and depth, calculating wetted area from a field developed creek cross section, and dividing velocity by wetted area to achieve flow according to the continuity of flow equation. By placing a small leaf in the creek and timing its travel over a set length, a velocity was determined. In order to find a representative velocity for the creek, this operation was performed three times, where the leaf was placed near the left bank, near the right bank, and around the center of the creek. The velocity corresponding to each leaf placement was added together and averaged to find a representative velocity.

Finally, the flow regime for the creek was estimated in the field by tossing a small rock in the center of the creek and noting the propagation of the ripples. When ripples propagate upstream, the flow regime is subcritical, while supercritical flow is denoted by downstream ripple propagation.

SITE VISIT SUMMARY			FORM 2
Project Information Route 888 4-lane		Computed: EKB	Date: 5/3/06
		Checked: JJL	Date: 5/5/06
Stream Name: Blue Creek	County: Sacramento	Route: 888	Postmile: 67.2

Obtain Physical Characteristics of Existing Culvert

Confined Spaces

Is the culvert height 5 ft or greater?	☐ Yes ☒ No
Can you stand up in the culvert?	☐ Yes ☒ No
Can you see all the way through the culvert?	☒ Yes ☐ No
Can you feel a breeze through the culvert?	☒ Yes ☐ No

If answer is "No" to any of the above questions, do not enter the culvert without confined spaces equipment for surveying.

Inlet Characteristics

Inlet Type	☒ Projecting	☐ Headwall	☐ Wingwall	
	☐ Flared end section	☐ Segment connection		
Inlet Condition	☒ Channel scour	☐ Excessive deposition	☐ Debris accumulation	☐ None applicable
Inlet Apron	☐ Channel scour	☐ Excessive deposition	☐ Debris accumulation	☒ None applicable

Skew Angle: NONE °	Upstream Invert Elevation: 320.96 ft (NGVD 29 or NAVD 88)

Barrel Characteristics

Diameter: 48 in	Fill height above culvert: 9.54 ft
Height/Rise: – ft	Length: 30 ft
Width/Span: – ft	Number of barrels: 1

Culvert Type	☐ Arch	☐ Box	☒ Circular
	☐ Pipe-Arch	☐ Elliptical	
Culvert Material	☐ HDPE	☐ Steel Plate Pipe	☐ Concrete Pipe
	☒ Spiral Rib / Corrugated Metal Pipe		
Barrel Condition	☐ Corrosion	☐ Debris accumulation	☐ Structural damage
	☒ Abrasion	☐ Bedload accumulation	☐ None applicable

SITE VISIT SUMMARY — FORM 2

Horizontal alignment breaks:	NONE ft	Vertical alignment breaks:	NONE ft

Outlet Characteristics

Outlet Type	☒ Projecting	☐ Headwall	☐ Wingwall	
	☐ Flared end section	☐ Segment connection		
Outlet Condition	☐ Scour hole	☐ Backwatered	☐ Debris accumulation	☒ None applicable
	☐ Perched	Outlet elevation drop: NONE ft		
		Outlet drop condition: Sandy- small rocks		
		Scour hole depth: NONE ft		
Outlet Apron	☐ Channel scour	☐ Excessive deposition	☐ Debris Accumulation	☒ None Applicable
Skew Angle: °		Downstream Invert Elevation: 320.80 ft (NGVD 29 or NAVD 88)		

Bridge Physical Characteristics N/A

Elevation of high chord (top of road): ft		Elevation of low chord: ft		
Channel Lining	☐ No lining	☐ Concrete	☐ Rock	☐ Other
Skew Angle: °		Bridge width (length): ft		

Pier Characteristics (if applicable) ☐ N/A

Number of Piers: ft		Upstream cross-section starting station: ft	
Pier Width: ft		Downstream cross-section starting station: ft	
Pier Centerline Spacing: ft			
Pier Shape	☐ Square nose and tail	☐ Semi-circular nose and tail	☐ 90° triangular nose and tail
	☐ Twin-cylinder piers with connecting diaphragm	☐ Twin-cylinder piers without connecting diaphragm	☐ Ten pile trestle bent
Pier Condition	☐ Scour	☐ Corrosion	☐ Debris accumulation
Skew angle °			

Channel Characteristics

Hydraulic Structure Roughness Coefficients

(Source: Caltrans Highway Design Manual Table 864.3A)		(Source: HEC-RAS User's Manual)	
Type of Structure	**n- value**	**Type of Structure**	**n- value (normal)**

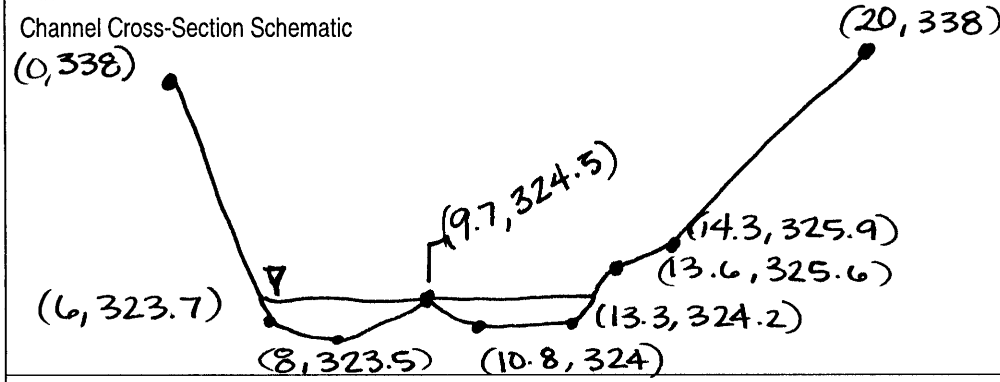
SITE VISIT SUMMARY			FORM 2
Linned Channels:		**Corrugated Metal:**	
Portland Cement Concrete	0.014	Subdrain	0.019
Air Blown Mortar (troweled)	0.012	Storm drain	0.024
Air Blown Mortar (untroweled)	0.016	**Wood:**	
Air Blown Mortar (roughened)	0.025	Stave	0.012
Asphalt Concrete	0.018	Laminated, treated	0.017
Sacked Concrete	0.025	**Brickwork:**	
Pavement and Gutters:		Glazed	0.013
Portland Cement Concrete	0.015	Lined with cement mortar	0.015
Asphault Concrete	0.016		
Depressed Medians:			
Earth (without growth)	0.040		
Earth (with growth)	0.050		
Gravel	0.055		

Recommended Permissible Velocities for Unlined Channels (Source: Caltrans Highway Design Manual, Table 862.2)

Type of Material in Excavation Section	Intermittent Flow (f/s)	Sustained Flow (f/s)
Fine Sand (Noncolloidal)	2.6	2.6
Sandy Loam (Noncolloidal)	2.6	2.6
Silt Loam (Noncolloidal)	3.0	3.0
Fine Loam	3.6	3.6
Volcanic Ash	3.9	3.6
Fine Gravel	3.9	3.6
Stiff Clay (Colloidal)	4.9	3.9
Graded Material (Noncolloidal)		
Loam to Gravel	6.6	4.9
Silt to Gravel	6.9	5.6
Gravel	7.5	5.9

Coarse Gravel	7.9	6.6
Gravel to Cobbles (Under 150mm)	8.8	6.9
Gravel and Cobbles Over 200mm)	9.8	7.9
Flow Estimation 5 cfs	☐ Supercritical flow	☒ Subcritical flow

Channel Cross-Section Schematic



Channel depth = 0.94 ft

Average Active Channel Width
Take at least five channel width measurments to determine the active channel width. The active channel stage or ordinary high water level is the elevation delineating the hightest water level that has been maintained for a sufficient period of time to leave evidence on the landscape.

Average Active Channel Width = 5.3 ft

1) 5.8 ft	2) 3.0 ft	3) 6.2 ft	4) 5.4 ft	5) 6.1 ft

Boundary Conditions
The normal depth option (slope area method) can only be used as a downstream boundary condition for an open-ended reach. Is normal depth appropriate? If no, what is the known starting water surface elevation? yes

Upstream Normal depth	slope 0.005 ft/ft
Downstream Normal depth	slope 0.005 ft/ft
Known starting water surface elevation Source:	— ft

General Considerations

Identify Physical restrictions

☐ Right-of-way ☐ Utility conflict ☐ Vegetation

☒ Man-made features ☐ Natural features ☐ Other

↳ Cylindical concrete structure pinches channel @ DS

Cross-Section Sketches Attached ☒ Yes ☐ No

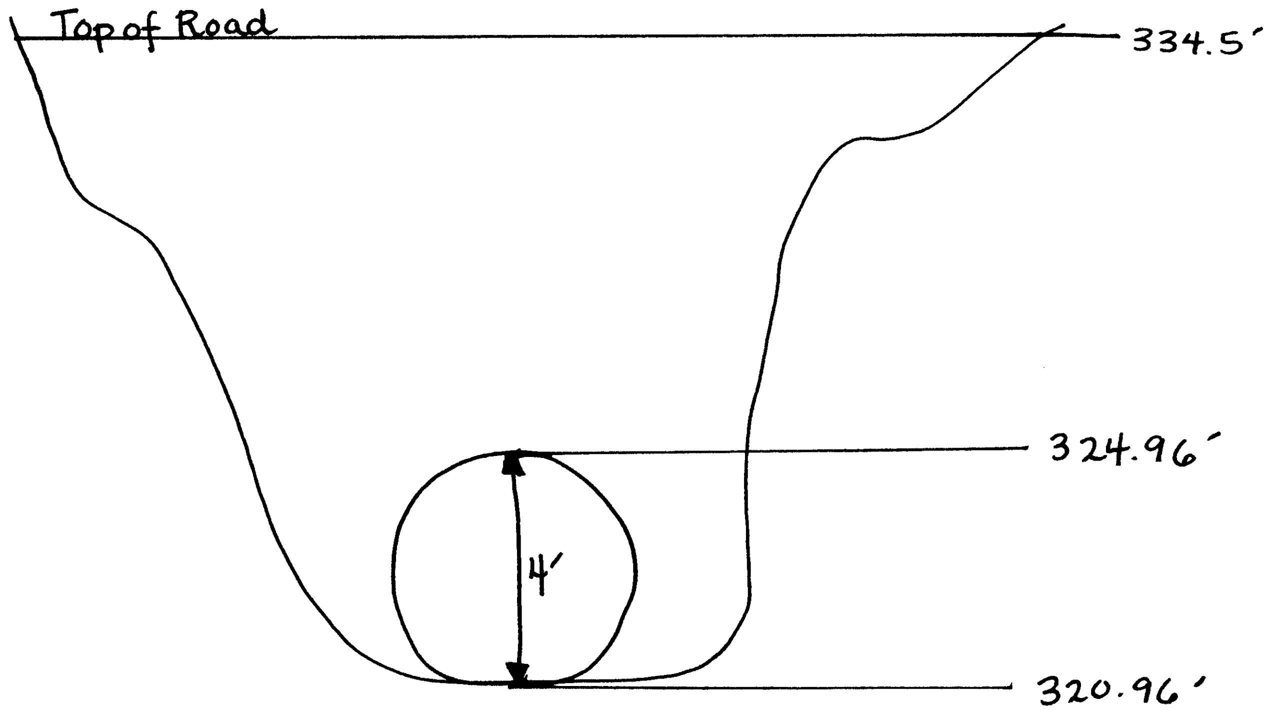
Site Photograph Documentation Attached ☒ Yes ☐ No

Channel / Overbank Manning's n-value Calculation Attached ☒ Yes ☐ No

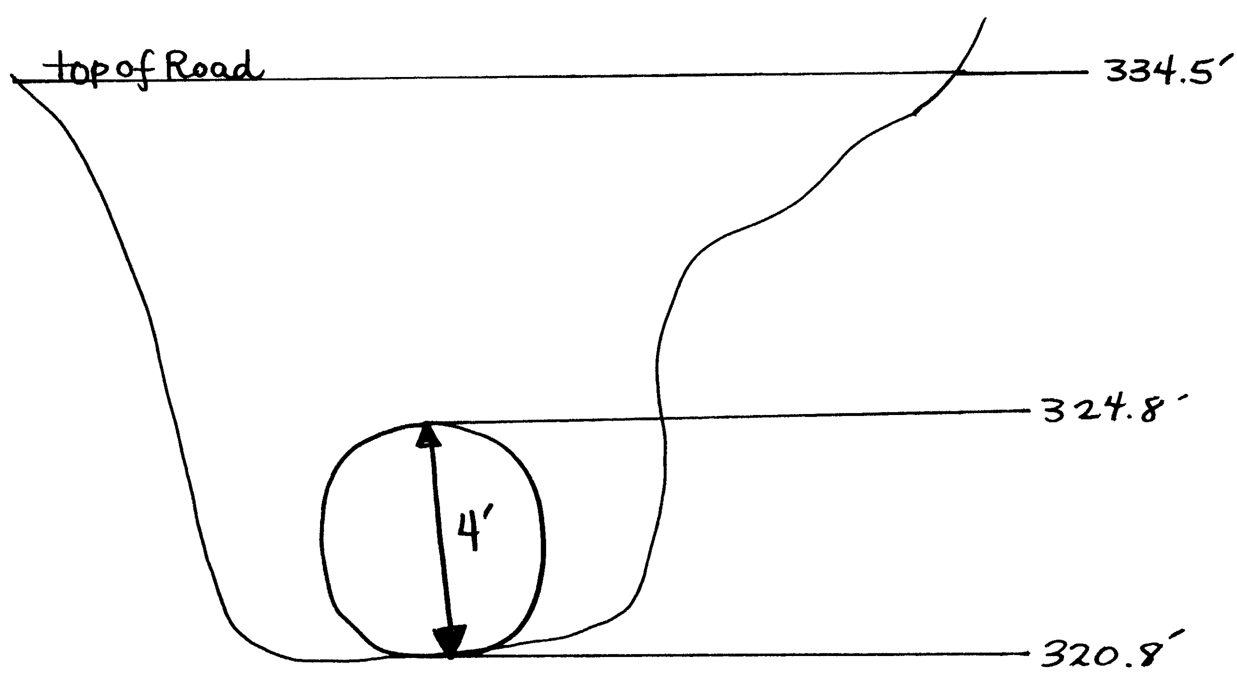
Field Notes Attached ☒ Yes ☐ No

Cross-Section Sketch

Upstream face of structure:

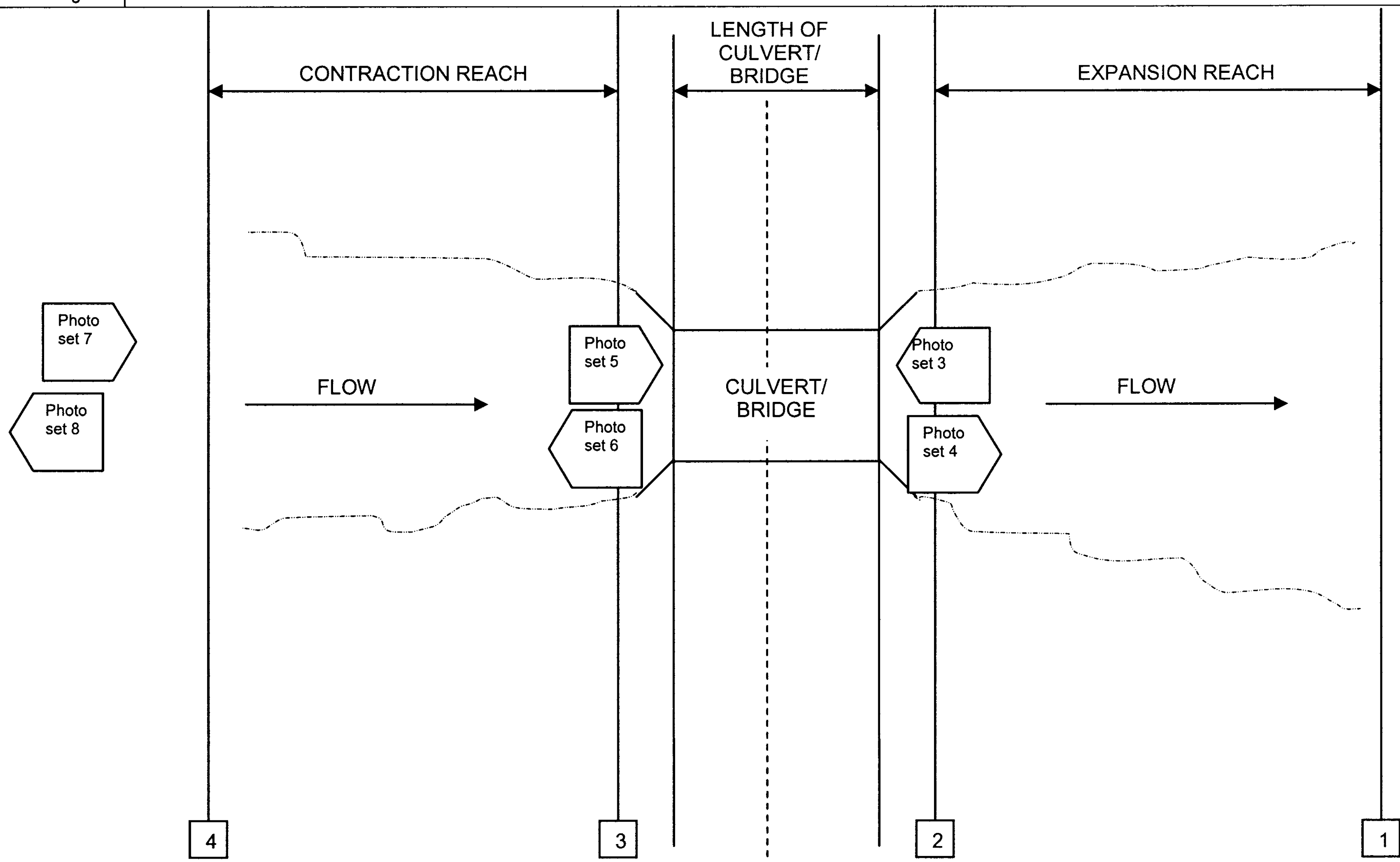


Downstream face of structure:



SITE PHOTOGRAPH DOCUMENTATION

Project Information Route 888 4-Lane				Computed: EKB		Date: 5/3/06	
				Checked: JJL		Date: 5/4/06	
Stream Name Blue Creek		City/County Folsom/Sacramento		Road 888		Postmile 67.2	
Crossing Type	☒ Culvert		☐ Bridge		☐ Other Type/Comments		
Distance From:	X-sec. 1 to X-sec. 2: 20 ft		X-sec. 2 to DS face of culvert 8 ft		US face of culvert to X-Sec. 3 2 ft	X-sec. 3 to X-sec. 4 40 ft	
Distance From:	Photo Sets 1 & 2 to DS face of culvert 105 ft		Photo Sets 3 & 4 to DS face of culvert 5 ft		Photo Sets 5 & 6 to US face of culvert 6 ft	Photo Sets 7 & 8 to US face of culvert 103 ft	
Length of Culvert/Bridge:	ft						



SITE PHOTOGRAPH DOCUMENTATION

Photo Descriptions:

Photo Set 1	2. JPG	Looking US of culvert inlet
Photo Set 2	15.JPG	Looking DS at culvert inlet
Photo Set 3	1a.JPG	Looking DS at inlet of culvert. NOTE: culvert projecting out of fill
Photo Set 4	17.JPG	Looking US of culvert inlet
Photo Set 5	16.JPG	Looking US at culvert outlet
Photo Set 6	25.JPG	Looking DS of culvert outlet NOTE: Concrete structure in channel
Photo Set 7	4.JPG	Looking US at culvert outlet
Photo Set 8	10.JPG	Looking DS of culvert outlet

Looking upstream of Culvert Inlet

Looking downstream at Culvert Inlet

Looking downstream at inlet of Culvert

Looking upstream of Culvert Inlet

Looking upstream at Culvert Outlet

Looking downstream of Culvert Outlet

Looking upstream at Culvert Outlet

Looking downstream of Culvert Outlet

Manning's n Computation Summary

Project Information		Computed: EKB	Date: 5/3/06
Route 888 4-Lane		Checked: JJL	Date: 5/4/06
Stream Name: Blue Creek	County: Sacramento	Route: 888	Postmile: 67.2

Aerial Picture Attached: yes

Photographs (#'s and locations) See individual channel & OB worksheets

Summary of n-Values:

Reach	**Left Overbank**	**Main Channel**	**Right Overbank**
	0.058	0.049	0.058

Notes:

Manning's n Computation - Main Channel

Project Information		Computed: EKB	Date: 5/3/06
Route 888 4-Lane		Checked: JJL	Date: 5/4/06
Stream Name: Blue Creek	County: Sacramento	Route: 888	Postmile: 67.2

Aerial Picture Attached: 1a, 1b, 2, 3, 4

Photographs (#'s and locations) 1a-culvert inlet facing DS, 1b-culvert outlet facing US
2-facing US @ culvert inlet
3-facing DS from culvert outlet
4-facing US @ culvert outlet

Is roughness uniform throughout the reach? NO

Note: If not, n-value should be assigned for the AVERAGE condition of the reach

Is roughness uniformly distributed along the cross section? NO

Is a division between the channel and floodplain necessary? yes

Calculation of n-value:

$n = (nb + n1 + n2 + n3 + n4)m$

where:

	Description of Range
nb = base n value for surface	*median size btwn 1" and 2.5"=0.028 to 0.035, btwn 2.5" and 10"=0.030 to 0.050*
n1 = surface irregularity factor	*smooth = 0 up to severe at 0.020*
n2 = cross section variation factor	*gradual = 0 up to alternating frequently at 0.015*
n3 = obstructions factor	*negligible = 0 up to severe (over 50% of cross section) at 0.05*
n4 = vegetation factor	*small = 0.002 to very large (average depth of flow is less than 1/2 height of vegetation) at 0.100*
m = sinuosity/meandering factor	*minor = 1.0, appreciable = 1.15, Severe = 1.30*

Base n value for surface

nb: Sand channel? NO if yes, median size of bed material? ________

nb =

median size (in)	nb
0.008	0.012
0.012	0.017
0.016	0.020
0.020	0.022
0.024	0.023
0.031	0.025
0.039	0.026

All other channels:

median size (in)	nb
.04 to .08	0.026 to 0.035
1 to 2.5	0.028 to 0.035
2.5 to 10	0.030 to 0.050
>10	0.040 to 0.070

Notes: Channel bottom consists of small rocks and soils. At downstream culvert exit finer soil sediment has accumulated. See Photos 1a and 1b

nb = 0.026

Manning's n Computation - Main Channel

Surface Irregularity

n1:	Smooth	Is channel smooth? NO	if yes, n1 = 0
	Minor	Is channel in good condition with slightly eroded or scoured side slopes?	if yes, n1 = 0.001 - 0.005
	Moderate	Is channel a dredged channel having moderate to considerable bed roughness and moderately sloughed or eroded side slopes in rock?	if yes, n1 = 0.006 - 0.010
	Severe	Is channel badly sloughed, scalloped banks or badly eroded or sloughed sides or jagged and irregular surface?	if yes, n1 = 0.011 - 0.020

Notes: Channel bottom has many elevation drops. All less than 1.0ft (see photo 2)

n1 = 0.006

Cross Section Variation Factor

n2:	Gradual	Does the size and shape of the channel cross section change gradually?	if yes, n2 = 0.000
	Alternately occasionally	Does the cross section alternate to large to small, *occasionally* or does the main flow *occasionally* shift from side to side?	if yes, n2 = 0.001 - 0.005
	Alternately frequently	Does the cross section alternate to large to small, *frequently* or does the main flow *frequently* shift from side to side?	if yes, n2 = 0.010 - 0.015

n2 = 0.005

Notes: The wetted X-section area does alternate a bit from side-to-side. (see photo 2)

Obstructions factor

n3:	Negligible	Does the stream have a few scattered obstructions that occupy < 5% of the cross-sectional area?	if yes, n3 = 0.000 - 0.004
	Minor	Obstructions occupy < 15% of the cross-sectional area and the spacing between obstructions is such that the sphere of influence doesn't extend to other obstructions?	if yes, n3 = 0.005 - 0.015
	Appreciable	Obstructions occupy 15% - 50% of the cross-sectional area and the spacing between obstructions is small enough to be additive?	if yes, n3 = 0.020 - 0.030
	Severe	Obstructions occupy more than 50% of the cross-sectional area or the spacing between obstructions causes turbulence?	if yes, n3 = 0.040 - 0.050

n3 = 0.004

Notes: There are few bolders that partially obstruct flow however, not a major concern. On the DS side of the culvert there is a large circular concrete structure that pinches the channel. (see photo 3)

Manning's n Computation - Main Channel

Vegetation factor

n4:

	Small	Does the channel have dense growth of flexible turf grass or weed growth where the flow is at least 2 times the height of the vegetation; tree seedlings of willows, cottonwoods, etc?	if yes, n4 = 0.002 - 0.010
	Medium	Does the channel have turf grass where the average depth of flow is 1 to 2 times the height of the vegetation; moderately stemmy grass, weeds or tree seedlings growing where the flow is 2 to 3 times the height of the vegetation?	if yes, n4 = 0.010 - 0.025
	Large	Does the channel where the average depth of flow is equal to the height of the vegetation; 8 to 10 years-old willows or cottonwoods intergrown with weeds and brush; where the hydraulic radius exceeds 0.6 m (1.97 ft) or bushy willows about 1 year old intergrown with some weeds along side slopes, and no significant vegetation exists along the channel bottom, where the hydraulic radius is greater than 0.61m (2.0 ft).	if yes, n4 = 0.025 -0.050
	Very large	Does the channel have turf grass growing where the average depth of flow < 1/2 the height of the vegetation; bushy willows about 1 year old. with weeds intergrown on side slopes; dense cattails in channel bottom; trees intergrown with weeds and brush?	if yes, n4 = 0.050 - 0.100

n4 = 0.008

Notes: Due to the rocky/gravel. channel bottom. Very little vegetation IS able to grow directly in the channel. (see photo 4)

Sinuosity/meandering factor

m	Minor	Ratio of the channel length to valley length in 1.0 to 1.2	if yes, m = 1.00
	Appreciable	Ratio of the channel length to valley length in 1.2 to 1.5	if yes, m = 1.15
	Severe	Ratio of the channel length to valley length > 1.5	if yes, m = 1.30

m = 1.0

Notes: NOT an ISSUE

Manning's n - Main Channel n = 0.049

Manning's n Computation - Overbank

Project Information	Computed: EKB	Date: 5/3/06
Route 888 4-lane	Checked: JJL	Date: 5/4/06
Stream Name: Blue Creek / County: Sacramento	Route: 888	Postmile: 67.2
Aerial Picture Attached: See channel photos		
Photographs (#'s and locations)		

Is roughness uniform throughout the reach? NO

Note: If not, n-value should be assigned for the AVERAGE condition of the reach

Is roughness uniformly distributed along the cross section? NO

Is a division between the channel and floodplain necessary? yes

Calculation of n-value:

$n = (nb + n1 + n2 + n3 + n4)m$

where:

	Description of Range
nb = base n value for surface	*median size between 1" and 2.5"=0.028 to 0.035, between 2.5" and 10"=0.030 to 0.050*
n1 = surface irregularity factor	*smooth = 0 up to severe at 0.020*
n2 = cross section variation factor	*gradual = 0 up to alternating frequently at 0.015*
n3 = obstructions factor	*assumed to equal 0*
n4 = vegetation factor	*small = 0.002 to very large (average depth of flow is less than 1/2 height of vegetation) at 0.100*
m = sinuosity/meandering factor	*equals 0 for floodplains*

Base n value for surface

nb: Sand channel? ________ if yes, median size of bed material? ________

nb =

median size (in)	nb
0.008	0.012
0.012	0.017
0.016	0.020
0.020	0.022
0.024	0.023
0.031	0.025
0.039	0.026

All other channels:

median size (in)	nb
.04 to .08	0.026 to 0.035
1 to 2.5	0.028 to 0.035
2.5 to 10	0.030 to 0.050
>10	0.040 to 0.070

Notes:

nb = 0.026

Surface Irregularity

n1:			
	Smooth	Compares to the smoothest, flattest floodplain in a given bed material.	if yes, n1 = 0
	Minor	Is the floodplain slightly irregular in shape. A few rises and dips or sloughs may be more visible on the floodplain.	if yes, n1 = 0.001 - 0.005
	Moderate	Has more rises and dips. Sloughs and hummocks may occur.	if yes, n1 = 0.006 - 0.010
	Severe	Floodplain very irregular in shape. Many rises and dips or sloughs are visible.	if yes, n1 = 0.011 - 0.020

n1 = 0.003

Notes:

Manning's n Computation - Overbank

Cross Section Variation Factor

n2 = 0.000

Notes: Not applicable to floodplains.

Obstructions factor

n3:

Negligible	Does the stream have a few scattered obstructions that occupy < 5% of the cross-sectional area?	if yes, n3 = 0.000 - 0.004
Minor	Obstructions occupy < 15% of the cross-sectional area and the spacing between obstructions is such that the sphere of influence doesn't extend to other obstructions?	if yes, n3 = 0.005 - 0.015
Appreciable	Obstructions occupy 15% - 50% of the cross-sectional area and the spacing between obstructions is small enough to be additive?	if yes, n3 = 0.020 - 0.030

n3 = 0.005

Notes:

Vegetation factor

n4:

Small	Does the channel have dense growth of flexible turf grass or weed growth where the flow is at least 2 times the height of the vegetation; tree seedlings of willows, cottonwoods, etc where the average depth of flow is at least three times the height of the vegetation?	if yes, n4 = 0.002 - 0.010
Medium	Does the channel have turf grass where the average depth of flow is 1-2 times the height of the vegetation; moderately stemmy grass, weeds or tree seedlings growing where the flow is 2-3 times the height of vegetation? Brushy, moderately dense vegetation, similar to 1-2 year old willow trees in dormant season.	if yes, n4 = 0.010 - 0.025
Large	Does the channel where the average. depth of flow is equal to the height of the vegetation; 8 to 10 year old. willows, cottonwoods intergrown with weeds and brush; where the R = 1.97 ft or bushy willows of 1 year old are in the channel bottom, where R =2.00 ft?	if yes, n4 = 0.025 -0.050
Very large	Does the channel have turf grass growing where the average depth of flow < 1/2 the height of the vegetation; bushy willows about 1 year old. with weeds intergrown on side slopes; dense cattails in channel bottom; trees intergrown with weeds and brush?	if yes, n4 = 0.050 - 0.100
Extreme	Does the channel have dense bushy willow, mesquite, and salt cedar (full foliage), or heavy stand of timber, few down trees, depth of reaching branches?	if yes, n4 = 0.100 - 0.200

n4 = 0.024

Notes: Much denser vegetation is present on overbanks than within channel

Sinuosity/meandering factor

m = 1.00

Notes: Not applicable to floodplains.

Manning's n - Overbank n = 0.058

Form 3 - Guidance on Selection of Fish Passage Design Option

Form 3 summarizes requirements for each design option in order for the designer to select the appropriate fish-passage design option.

Because specific target species and their swimming abilities are not known for this project, which is needed when using the Hydraulic Design strategy, only the Stream Simulation and Active Channel strategies are initially viable. By using either of these design options, passage can be satisfied for all fish, both are suitable design options for culvert replacement, and both options can be used for the proposed culvert slope of 0.5%

For Blue Creek, the 68-foot proposed culvert length controls the choice of design option. When designing a fish passage culvert, its length must be greater than 100 feet for the Stream Simulation option. Therefore, the Active Channel design option is the best strategy for fish-passage design at Blue Creek.

Given the new, larger diameter culvert and its potential to convey higher flow more effectively, District Hydraulics must be consulted so that any negative impacts to downstream properties or facilities can be assessed prior to final design.

GUIDANCE ON SELECTION OF FISH PASSAGE DESIGN OPTION — FORM 3

Project Information Route 888 4-Lane		Computed: EKB	Date: 5/3/06
		Checked: JJL	Date: 5/4/06
Stream Name:	County:	Route: 888	Postmile: 67.2

Design Species/ Life Stage		
	☒	All Species
	☐	Adult Anadromous Salmonids
	☐	Adult Non-Anadromous Salmonids
	☐	Juvenile Salmonids
	☐	Native Non-Salmonids
	☐	Non-Native Species

☒ **Active Channel Design Option -** The Active Channel Design Option is a simplified design method that is intended to size a crossing sufficiently large and embedded deep enough into the channel to allow the natural movement of bedload and formation of a stable streambed inside the culvert. Determination of the high and low fish passage design flows, water velocity, and water depth is not required for this option since with stream hydraulic charagcteristics within the culvert are intended to mimic the stream conditions upstream and downstream of the crossing. However, hydraulic analyses for traffic safety, hydraulic impacts, and scour are required.

Criteria for choosing option:

- ☒ New and replacement culvert/bridge installations
- ☒ Passage required for all species
- ☒ Proposed culver/bridge length less than 100 feet
- ☒ Channel slope less than 3%

☐ **Hydraulic Design Option -** The Hydraulic Design Option is a design process that matches the hydraulic performance of a culvert with the swimming ablitities of a target species and age class of fish. This method targets distinct species of fish and, therefore, does not account for ecosystem requirments of non-target species.

Criteria for choosing option:

- ☒ New and replacement culvert/bridge installations (If retrofit installation, see Baffle or Rock Weir Design Options)
- ☐ Target species identified for passage
- ☒ Low to moderate channel slopes (less than 3%)
- ☐ Active channel design or stream simulation design options are not physically feasible

Retrofit Culvert/Bridge Installations

☐ **Baffle Design Option -** The Baffle Design Option is a Hydrualic Design process that is intended to increase flow depth, or to add roughness elements as a measure to reduce flow velocity within the culvert/bridge structure. Determination of the high and low fish passage design flows, water velocity, and water depth is required for this option.

- ☐ Retrofit culvert/bridge installation
- ☐ Little bedload material movement

GUIDANCE ON SELECTION OF FISH PASSAGE DESIGN OPTION — FORM 3

- ☐ Existing culvert/bridge is structurally sound
- ☐ Target species identified for passage
- ☐ Low to moderate channel slopes
- ☐ Active channel design or stream simulation design options are not physically feasible

☐ **Rock Weir Design Option -** The Rock Weir Design Option is a Hydraulic Design process that is intended to increase flow depth, or add roughness elements as a measure to reduce flow velocity, or to increase the channel slope downstream of the culvert/bridge. Determination of the high and low fish passage design flows, water velocity, and water depth is required for this option.

- ☐ Retrofit culvert/bridge installations
- ☐ Perched condition at outlet
- ☐ Steep slope at inlet
- ☐ Target species identified for passage
- ☐ Active channel design or stream simulation design options are not physically feasible

☐ **Stream Simulation Design Option -** The Stream Simulation Design Option is a design process that is intended to mimic the natural stream processes within a culvert. Fish passage, sediment transport, flood and debris conveyance within the crossing are intended to function as they would in a natural channel. Determination of the high and low fish passage design flows, water velocity, and water depth is not required for this options since the stream hydraulic characteristics within the culvert are designed to mimic the stream conditions upstream and downstream of the crossing.

Criteria for choosing option:

- ☒ New and replacement culvert/bridge installations
- ☒ Passage required for all species
- ☐ Culvert/bridge length greater than 100 feet
- ☒ Channel width should be less than 20 feet
- ☐ Minimum culvert/bridge width no less than 6 feet
- ☐ Culvert/bridge slope does not greatly exceed slope of natural channel, slopes of 6 % or less
- ☐ Narrow stream valleys

Selected Design Option: Active Channel Design

Basis for Selection:
- Replacement culvert
- all species required to pass
- Proposed culvert length is 68ft < 100ft
- Channel slope is 0.5%

Seek Agency Approval: ☐ Yes ☒ No

Form 4 - Guidance on Methodology for Hydrologic Analysis

Form 4 summarizes methods for estimating peak design discharges that will be used in a hydraulic analysis. Data requirements, limitations, and guidance are provided to assist in the hydrologic method selection.

For this particular example, all data requirements needed to calculate peak discharges by regional regression equations were readily available. These peak discharges were compared to the effective Flood Insurance Study; however, the new peak discharges were calculated completely independent of the effective study.

Project Information	Computed: EKB	Date: 5/4/06
Route 888 4-lane	Checked: JJL	Date: 5/5/06
Stream Name: Blue Creek / County: Sacramento	Route: 888	Postmile: 67.2

Summary of Methods for Estimating Peak Design Discharges for Use in Hydraulic Analysis

Ungaged Streams

☒ **Regional Regression[3,4]**

Data Requirements	Limitations	Guidance
▪ Drainage area ▪ Mean annual precipitation ▪ Altitude index	▪ Peak discharge value for flow under natural conditions unaffected by urban development and little or no regulation by lakes or reservoirs ▪ Ungaged channel	The most recently published USGS report for estimating peak discharges may be used. The user should exercise caution to ensure that the reports are used only for the conditions and locations for which they are recommended.

Rainfall-Runoff Models

☐ **NRCS (TR 55)[5]**

Data Requirements	Limitations	Guidance
▪ 24-hour Rainfall ▪ Rainfall distribution ▪ Runoff curve number ▪ Concentration time ▪ Drainage area	▪ Small or midsize catchment (<8 km^2) ▪ Maximum of 10 subwatersheds ▪ Concentration time range from 0.1-10 hour (tabular hydrograph method limit <2 hour) ▪ Runoff is overland and channel flow ▪ Simplified channel routing ▪ Negligible channel storage	TR-55 focuses on small urban and urbanizing watersheds.

☐ **HEC-1/HEC-HMS[6,7] (SCS Dimnesionless, Snyder Unit, Clark Unit Hydrographs)**

Data Requirements	Limitations	Guidance
▪ Watershed/subbasin parameters ▪ Precipitation depth, duration, frequency, and distribution ▪ Precipitation losses ▪ Unit hydrograph parameters ▪ Streamflow routing and diversion parameters	▪ Simulations are limited to a single storm event ▪ Streamflow routing is performed by hydrologic routing methods and is therefore not appropriate for unsteady state routing conditions.	Can be used for watersheds which are: small or large, simple or complex, and developed or undeveloped.

[1] Caltrans Highway Design Manual, Chapter 810 Hydrology, Topic 819 Estimating Design Discharge
[2] FEMA Guidelines and Specifications, Appendix C, Section C.1
[3] USGS Water-Resources Investigation 77-21 (Magnitude and Frequency of Floods in California)
[4] USGS Open-File Report 93-419 (Methods for Estimating Magnitude and Frequency of floods in the Southwestern United States)
[5] United States Department of Agriculture, Natural Resources Conservation Service, Urban Hydrology for Small Watersheds Technical Release 55, June 1986. ftp://ftp.wcc.nrcs.usda.gov/downloads/hydrology_hydraulics/tr55/tr55.pdf
[6] HEC-1 User's Manual
[7] HEC-HMS User's Manual
[8] Bulletin 17B

GAGED STREAMS

☐ **Statistical Methods**[8]

Data Requirements	Limitations	Guidance
▪ 10 or more years of gaged flood records	▪ Gage data is usually only available for midsized and large catchments ▪ Appropriate station and/or generalized skew coefficient relationship applied	For watersheds with less than 50 years of record, compare with results of appropriate USGS regional regression equations. For watersheds with less than 25 years of record, compare with results of appropriate USGS regional regresssion equations and/or HEC-1/HEC-HMS model results.

☐ **Basin Transfer of Gage Data**

Data Requirements	Limitations	Guidance
▪ Discharge and area for gaged watershed ▪ Area for ungaged watershed	▪ Similar hydrologic characteristics ▪ Channel storage	Must obtain approval of transfer technique from hydraulics engineer prior to use.

☐ **Fish Passage Flows**

▪ Streamflow hydrograph ▪ Flow duration curve		Lower and upper fish passage flows define the range of flows a culvert should contain suitable conditions for fish passage.

Selected Hydrologic Method: Regional Regression

Basis for Selection:

Peak discharges calculated seem reasonable and appropriate for a subbasin of 0.53 mi2 drainage area

[1] Caltrans Highway Design Manual, Chapter 810 Hydrology, Topic 819 Estimating Design Discharge
[2] FEMA Guidelines and Specifications, Appendix C, Section C.1
[3] USGS Water-Resources Investigation 77-21 (Magnitude and Frequency of Floods in California)
[4] USGS Open-File Report 93-419 (Methods for Estimating Magnitude and Frequency of floods in the Southwestern United States)
[5] United States Department of Agriculture, Natural Resources Conservation Service, Urban Hydrology for Small Watersheds Technical Release 55, June 1986. ftp://ftp.wcc.nrcs.usda.gov/downloads/hydrology_hydraulics/tr55/tr55.pdf
[6] HEC-1 User's Manual
[7] HEC-HMS User's Manual
[8] Bulletin 17B

GUIDANCE ON METHODOLOGY FOR HYDROLOGIC ANALYSIS [1,2]	FORM 4

Verify Reasonableness and Recommended Flows

Source	50% Annual Probability (2-Year Flood Event) (cfs)	10% Annual Probability (10-Year Flood Event) (cfs)	2% Annual Probability (50-Year Flood Event) (cfs)	1% Annual Probability (100-Year Flood Event) (cfs)	High Fish Passage Design Flow (cfs)	Low Fish Passage Design Flow (cfs)
Effective Study Peak Discharges	22	100	203	252	N/A	N/A
Recommended Peak Discharges	30	106	222	284	N/A	N/A

Hydrologic Analysis Index Attached ☒ Yes ☐ No

Hydrologic Analysis Calculations Attached ☒ Yes ☐ No

[1] Caltrans Highway Design Manual, Chapter 810 Hydrology, Topic 819 Estimating Design Discharge
[2] FEMA Guidelines and Specifications, Appendix C, Section C.1
[3] USGS Water-Resources Investigation 77-21 (Magnitude and Frequency of Floods in California)
[4] USGS Open-File Report 93-419 (Methods for Estimating Magnitude and Frequency of floods in the Southwestern United States)
[5] United States Department of Agriculture, Natural Resources Conservation Service, Urban Hydrology for Small Watersheds Technical Release 55, June 1986. ftp://ftp.wcc.nrcs.usda.gov/downloads/hydrology_hydraulics/tr55/tr55.pdf
[6] HEC-1 User's Manual
[7] HEC-HMS User's Manual
[8] Bulletin 17B

HYDROLOGIC ANALYSES INDEX

FORM 4

Project Information		Computed: EKB	Date: 5/4/06
Route 888 4-Lane		Checked: JJL	Date: 5/5/06
Stream Name: Blue Creek	County: Sacramento	Route: 888	Postmile: 67.2

Flooding Source/Stream Name	Hydrologic Method/Model Used	Method/Model Analysis Date	Exhibit No.	
			Paper Copy	Electronic Copy
Blue Creek	Regional Regression	Site located in Sierra Region, CA	1	–
Source:	Nationwide summary of USGS Regional Regression Equations for Estimating Magnitude + Frequency of Floods for Ungaged Sites, 1993.			

Regional Regression Computation Summary

Project Information:	Route 888 4-Lane			Computed:	EKB	Date:	5/4/2006
				Checked:	JJL	Date:	5/5/2006
Stream Name:	Blue Creek	County:	City of Folsom Sacramento County	Route:	888	Postmile:	67.2

Calculations:

-Site Located in Sierra Region

A, Drainage Area = 0.53 mi^2
P, Mean Annual Precipitation = 17 inches
H, Altitude Index = 0.317 thousands of feet

Regional Regression Equations

$Q2 = 0.24A^{0.88}P^{1.58}H^{-0.80}$
Q2 = 30 cfs

$Q5 = 1.20A^{0.82}P^{1.37}H^{-0.64}$
Q5 = 72 cfs

$Q10 = 2.63A^{0.80}P^{1.25}H^{-0.58}$
Q10 = 106 cfs

$Q25 = 6.55A^{0.79}P^{1.12}H^{-0.52}$
Q25 = 172 cfs

$Q50 = 10.4A^{0.78}P^{1.06}H^{-0.48}$
Q50 = 222 cfs

$Q100 = 15.7A^{0.77}P^{1.02}H^{-0.43}$
Q100 = 284 cfs

The following documentation was taken from:

U.S. Geological Survey Water-Resources Investigations Report 94-4002:
Nationwide summary of U.S. Geological Survey regional regression equations for estimating magnitude and frequency of floods for ungaged sites, 1993

CALIFORNIA

STATEWIDE RURAL

Summary

California is divided into six hydrologic regions (fig. 1). The regression equations developed for these regions are for estimating peak discharges (QT) having recurrence intervals T that range from 2 to 100 years. The explanatory basin variables used in the equations are drainage area (A), in square miles; mean annual precipitation (P), in inches; and an altitude index (H), which is the average of altitudes in thousands of feet at points along the main channel at 10 percent, and 85 percent of the distances from the site to the divide. The variables A and H may be measured from topographic maps. Mean annual precipitation (P) is determined from a map in Rantz (1969). The regression equations were developed from peak-discharge records of 10 years or longer, available as of 1975, at more than 700 gaging stations throughout the State. The regression equations are applicable to unregulated streams but are not applicable to some parts of the State (see fig. 1). The standard errors of estimate for the regression equations for various recurrence intervals and regions range from 60 to over 100 percent. The report by Waananen and Crippen (1977) includes an approximate procedure for increasing a rural discharge to account for the effect of urban development. The influences of fire and other basin changes on flood magnitudes are also discussed.

Procedure

Topographic maps, the hydrologic regions map (fig. 1), the mean annual precipitation from Rantz (1969), and the following equations are used to estimate the needed peak discharges QT, in cubic feet per second, having selected recurrence intervals T.

North Coast Region

$Q2 = 3.52\,A^{0.90}\,P^{0.89}\,H^{-0.47}$
$Q5 = 5.04\,A^{0.89}\,P^{0.91}\,H^{-0.35}$
$Q10 = 6.21\,A^{0.88}\,P^{0.93}\,H^{-0.27}$
$Q25 = 7.64\,A^{0.87}\,P^{0.94}\,H^{-0.17}$
$Q50 = 8.57\,A^{0.87}\,P^{0.96}\,H^{-0.08}$
$Q100 = 9.23\,A^{0.87}\,P^{0.97}$

Northeast Region

$Q2 = 22\,A^{0.40}$
$Q5 = 46\,A^{0.45}$
$Q10 = 61\,A^{0.49}$
$Q25 = 84\,A^{0.54}$
$Q50 = 103\,A^{0.57}$
$Q100 = 125\,A^{0.59}$

Sierra Region

$Q2 = 0.24\,A^{0.88}\,P^{1.58}\,H^{-0.80}$
$Q5 = 1.20\,A^{0.82}\,P^{1.37}\,H^{-0.64}$
$Q10 = 2.63\,A^{0.80}\,P^{1.25}\,H^{-0.58}$
$Q25 = 6.55\,A^{0.79}\,P^{1.12}\,H^{-0.52}$
$Q50 = 10.4\,A^{0.78}\,P^{1.06}\,H^{-0.48}$
$Q100 = 15.7\,A^{0.77}\,P^{1.02}\,H^{-0.43}$

Central Coast Region

$Q2 = 0.0061\,A^{0.92}\,P^{2.54}\,H^{-1.10}$
$Q5 = 0.118\,A^{0.91}\,P^{1.95}\,H^{-0.79}$
$Q10 = 0.583\,A^{0.90}\,P^{1.61}\,H^{-0.64}$
$Q25 = 2.91\,A^{0.89}\,P^{1.26}\,H^{-0.50}$
$Q50 = 8.20\,A^{0.89}\,P^{1.03}\,H^{-0.41}$
$Q100 = 19.7\,A^{0.88}\,P^{0.84}\,H^{-0.33}$

South Coast Region

$Q2 = 0.14\,A^{0.72}\,P^{1.62}$
$Q5 = 0.40\,A^{0.77}\,P^{1.69}$
$Q10 = 0.63\,A^{0.79}\,P^{1.75}$
$Q25 = 1.10\,A^{0.81}\,P^{1.81}$
$Q50 = 1.50\,A^{0.82}\,P^{1.85}$
$Q100 = 1.95\,A^{0.83}\,P^{1.87}$

South Lahontan-Colorado Desert Region

$$Q2 = 7.3A^{0.30}$$
$$Q5 = 53A^{0.44}$$
$$Q10 = 150A^{0.53}$$
$$Q25 = 410A^{0.63}$$
$$Q50 = 700A^{0.68}$$
$$Q100 = 1080A^{0.71}$$

In the North Coast region, use a minimum value of 1.0 for the altitude index (H). Equations are defined only for basins of 25 mi^2 or less in the Northeast and South Lahontan-Colorado Desert regions.

Reference

Waananen, A.O., and Crippen, J.R., 1977, Magnitude and frequency of floods in California: U.S. Geological Survey Water-Resources Investigations Report 77-21, 96 p.

Additional Reference

Rantz, S.E., 1969, Mean annual precipitation in the California region: U.S. Geological Survey Open-File Map (Reprinted 1972, 1975).

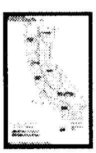


Figure 1. Flood-frequency region map for California. (PostScript file of Figure 1.)

Back to NFF main page

USGS Surface-Water Software Page

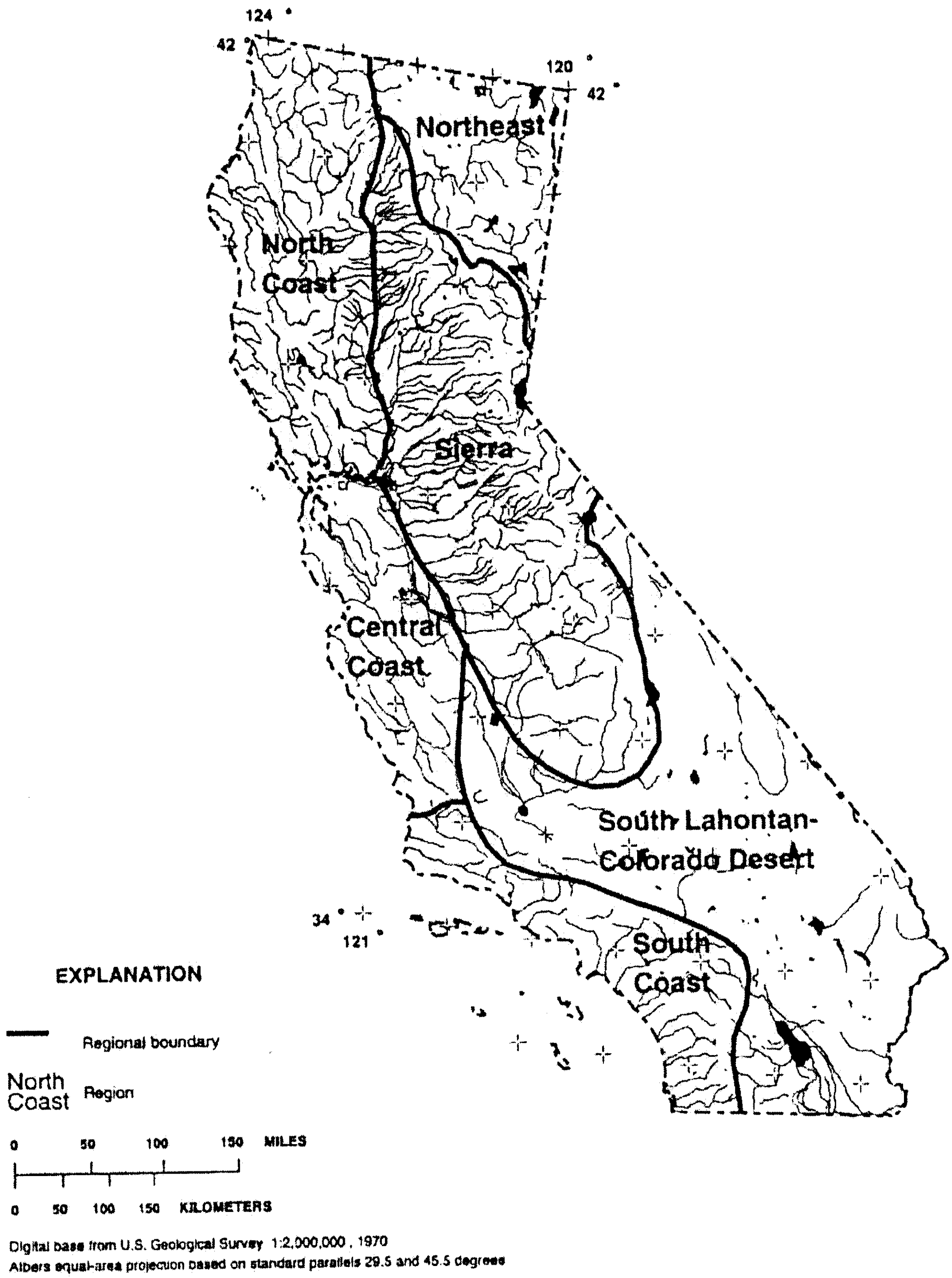


Figure 1. Flood-frequency region map for California.

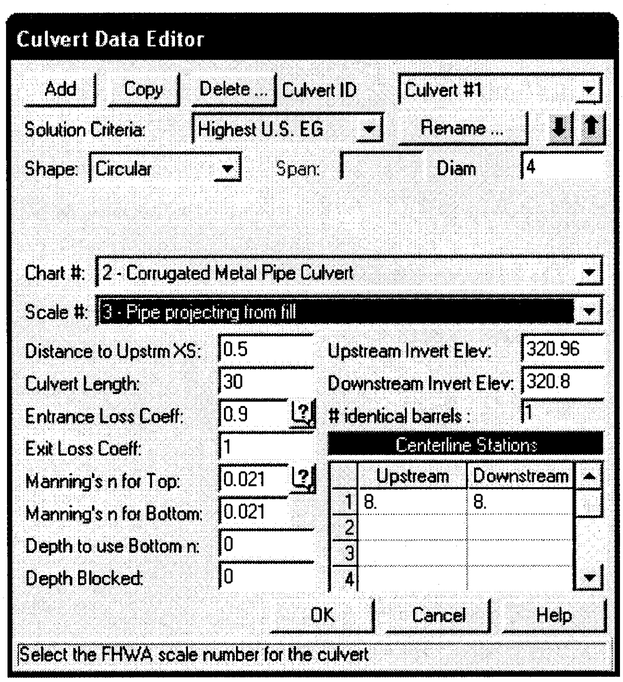
Form 5 - Guidance on Methodology for Hydraulic Analysis

Form 5 summarizes the acceptable methods available for hydraulic analysis. The modeling methods include FHWA Design Charts, HY8 - Culvert Analysis, and HEC-2/HEC-RAS.

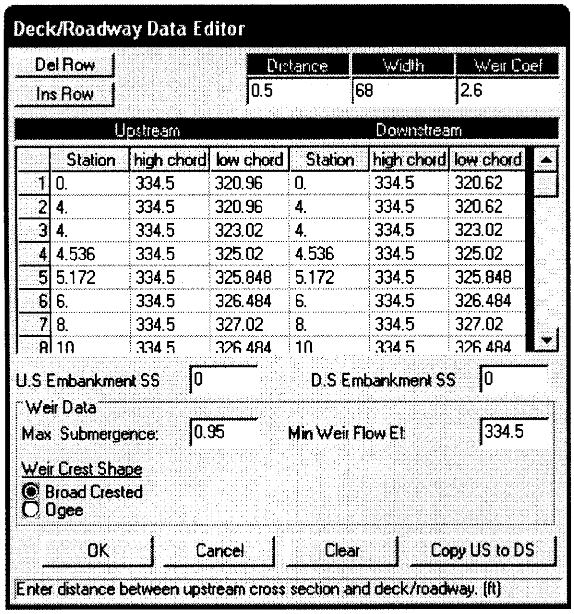
For this particular example, HEC-RAS was used to model existing and proposed conditions. HEC-RAS easily allowed a quick comparison between existing and proposed water surface elevations and velocities.

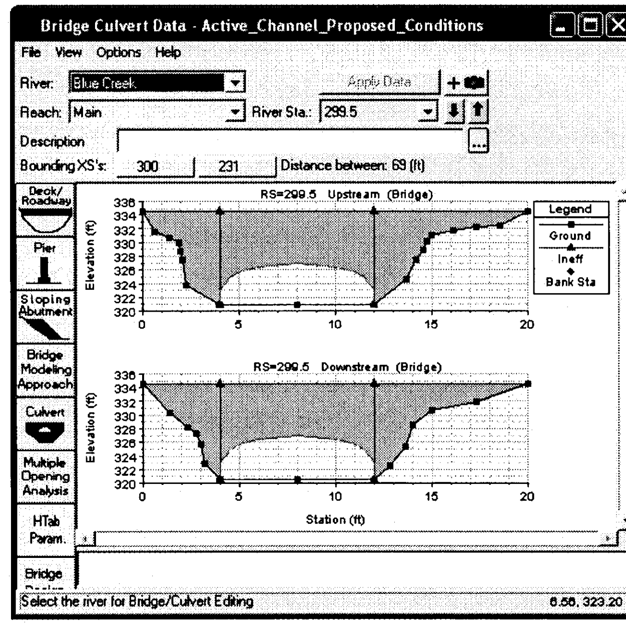
The HEC-RAS model consists of two plans: existing geometry and proposed geometry conditions. Both plans use the same peak discharges estimated by regional regression analysis.

The existing culvert geometry was modeled using the Culvert Data Editor. The existing culvert parameters that had been measured and captured in Form 2 - Site Visit Summary, were entered into the Culvert Data Editor in HEC-RAS.



The proposed culvert geometry was modeled using the Deck/Roadway Data Editor. The proposed culvert geometry could not be modeled using the standard Culvert Data Editor due to the different embedment depths at the culvert inlet and outlet. Instead, the proposed culvert geometry was modeled by manually entering the low chord elevations into the Deck/Roadway Data Editor.


Deck/Roadway Data Editor
Del Row
Ins Row
Distance
Width
Weir Coef
0.5
68
2.6
Upstream
Downstream
Station | high chord | low chord | Station | high chord | low chord
1 | 0. | 334.5 | 320.96 | 0. | 334.5 | 320.62
2 | 4. | 334.5 | 320.96 | 4. | 334.5 | 320.62
3 | 4. | 334.5 | 323.02 | 4. | 334.5 | 323.02
4 | 4.536 | 334.5 | 325.02 | 4.536 | 334.5 | 325.02
5 | 5.172 | 334.5 | 325.848 | 5.172 | 334.5 | 325.848
6 | 6. | 334.5 | 326.484 | 6. | 334.5 | 326.484
7 | 8. | 334.5 | 327.02 | 8. | 334.5 | 327.02
8 | 10 | 334.5 | 326.484 | 10 | 334.5 | 326.484
U.S Embankment SS 0
D.S Embankment SS 0
Weir Data
Max Submergence: 0.95
Min Weir Flow El: 334.5
Weir Crest Shape
Broad Crested
Ogee
OK
Cancel
Clear
Copy US to DS
Enter distance between upstream cross section and deck/roadway. (ft)


Bridge Culvert Data - Active_Channel_Proposed_Conditions
File View Options Help
River: Blue Creek
Apply Data
Reach: Main
River Sta.: 299.5
Description
Bounding XS's: 300 231 Distance between: 69 (ft)
Deck/Roadway
Pier
Sloping Abutment
Bridge Modeling Approach
Culvert
Multiple Opening Analysis
HTab Param.
Bridge
RS=299.5 Upstream (Bridge)
Legend
Ground
Ineff
Bank Sta
Elevation (ft)
RS=299.5 Downstream (Bridge)
Station (ft)
Select the river for Bridge/Culvert Editing
6.58, 323.20

GUIDANCE ON METHODOLOGY FOR HYDRAULIC ANALYSIS		FORM 5	
Project Information Route 888 4-Lane		Computed: EKB	Date: 5/6/06
		Checked: JJL	Date: 5/7/06
Stream Name: Blue Creek	County: Sacramento	Route: 888	Postmile: 67.2

Summary of Methods for Hydraulic Analysis

☐ **FHWA Design Charts**

☐ **HY8 - Culvert Analysis or other HDS-5 Based Software**

☒ **HEC-2 / HEC-RAS**

☐ **Fish Xing (Pre-design assessment or post-design assessment when applicable)**

Is the hydraulic model used to create the effective FIRM available? ☐ Yes ☒ No
If yes, update and use this model for the hydraulic model.

Selected Method: HEC-RAS

Basis for Selection:

- X-section geometry for upstream and downstream available
- Steady flow Modeling

Verify Reasonableness and Recommended Flows ☒ Yes ☐ No

Hydraulic Analyses Index Attached ☒ Yes ☐ No

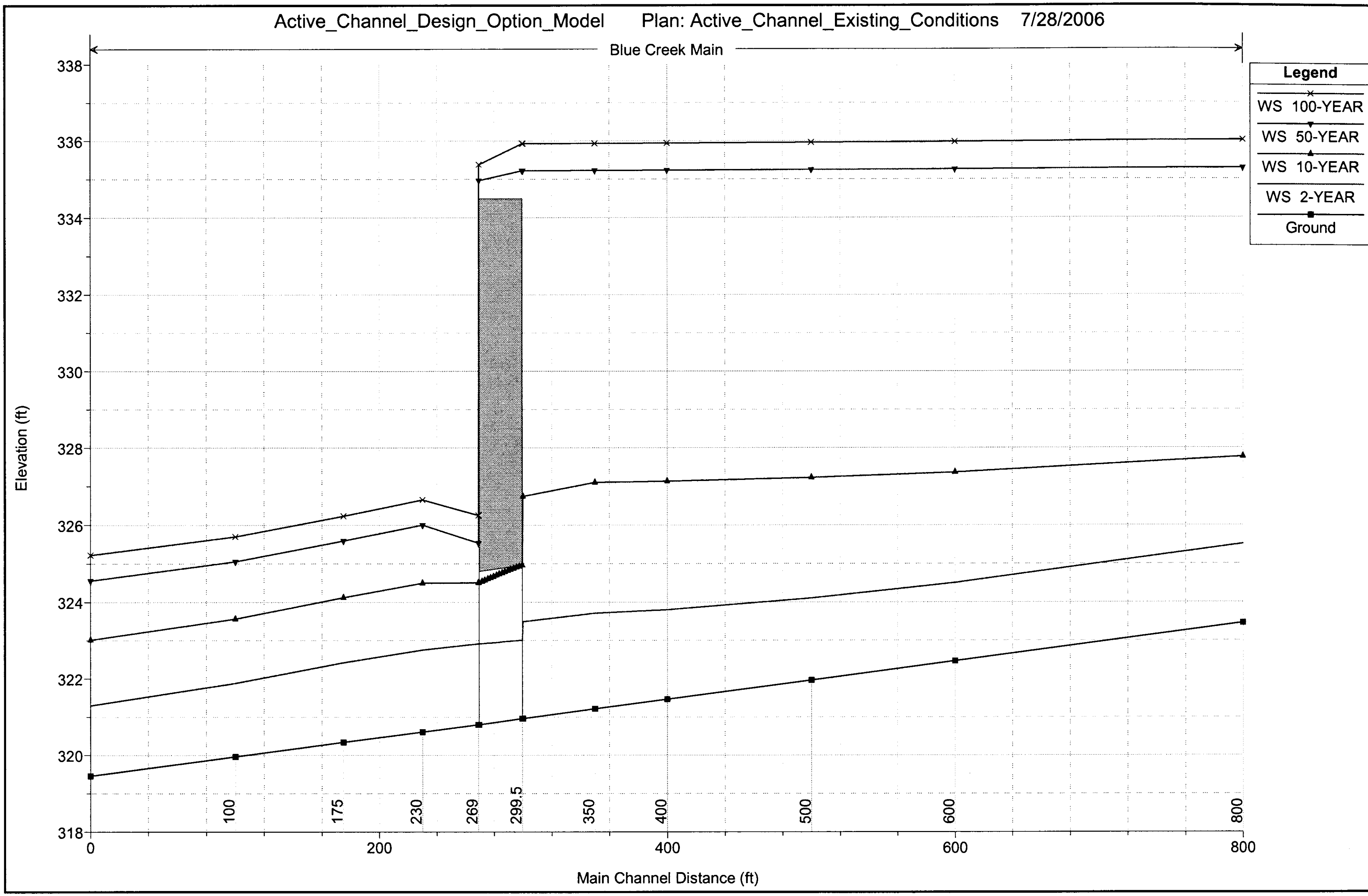
Hydraulic Analysis Calculation Attached ☒ Yes ☐ No

HYDRAULIC ANALYSES INDEX — FORM 5

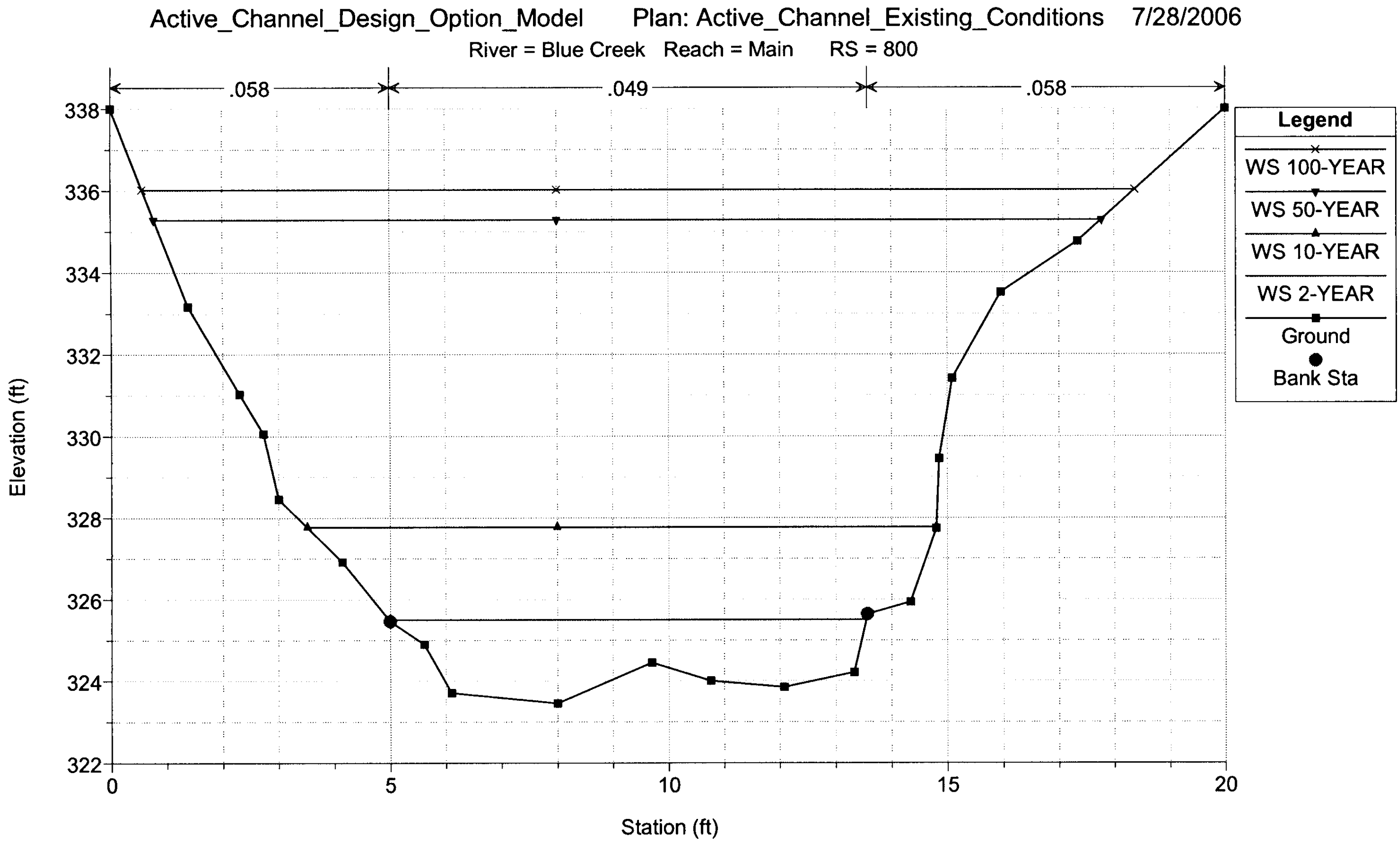
Project Information	Computed: EKB	Date: 5/6/06
Route 888 4-lane	Checked: JJL	Date: 5/7/06

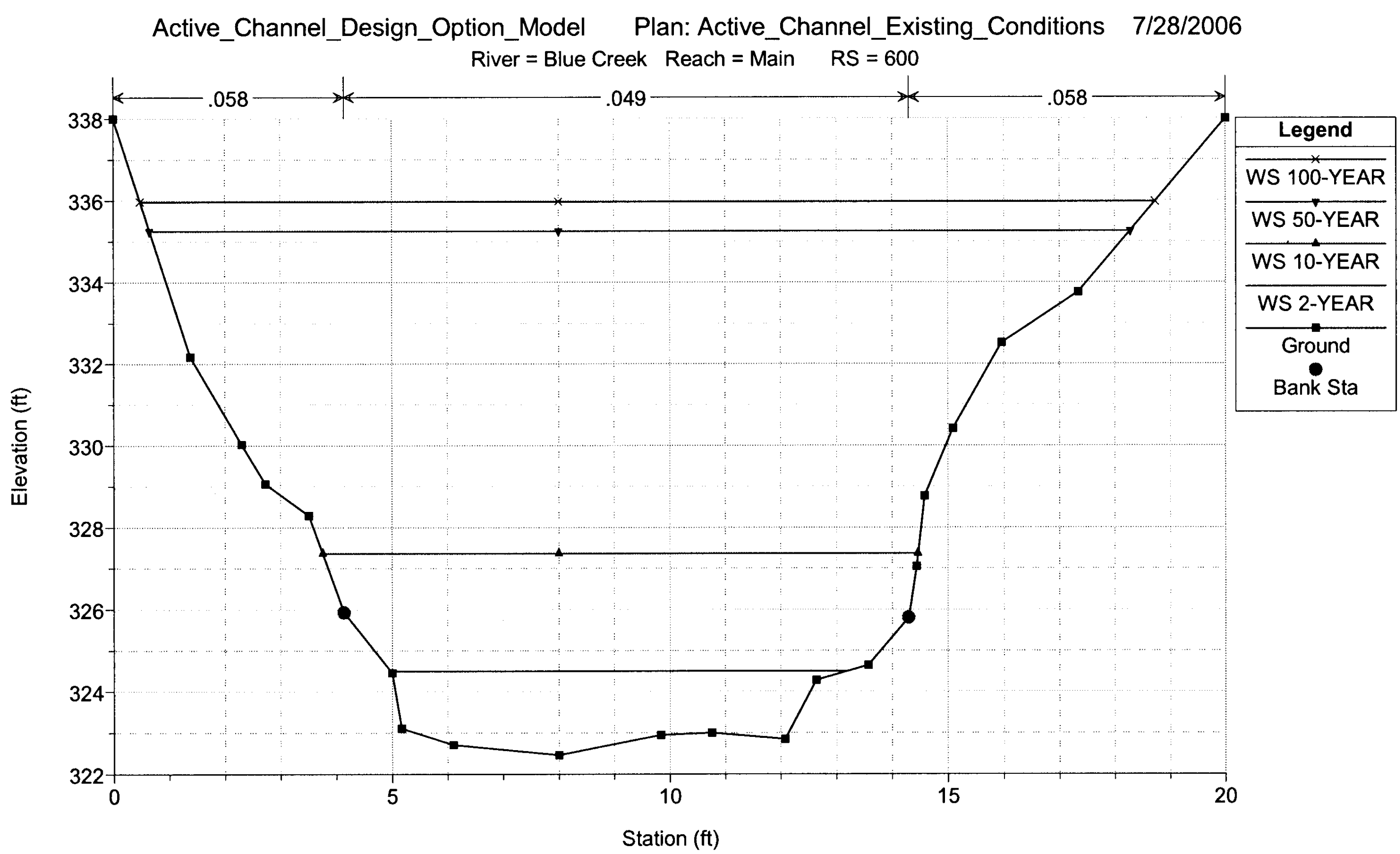
Stream Name: Blue Creek	County: Sacramento	Route 888	Postmile 67.2

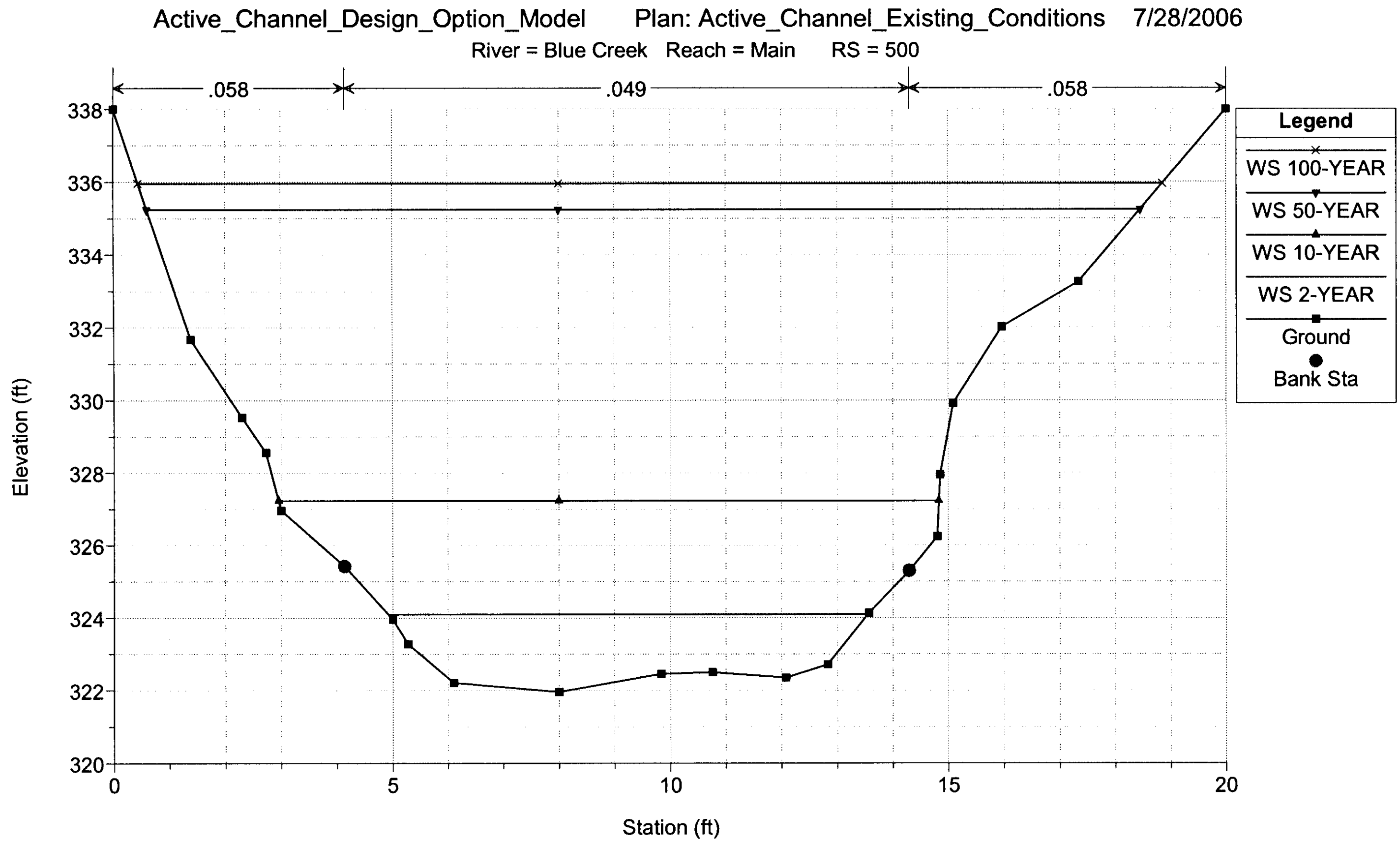
Flooding Source/Stream Name	Hydraulic Method/Model Used	Method/Model Analysis Date	Exhibit No.	
			Paper Copy	Electronic Copy
Blue Creek	HEC-RAS	5/6/06	1	
	→ Existing	conditions model		.p01 .g01
				.f01
	→ Proposed	Conditions model		.p02 .g02
				.f02

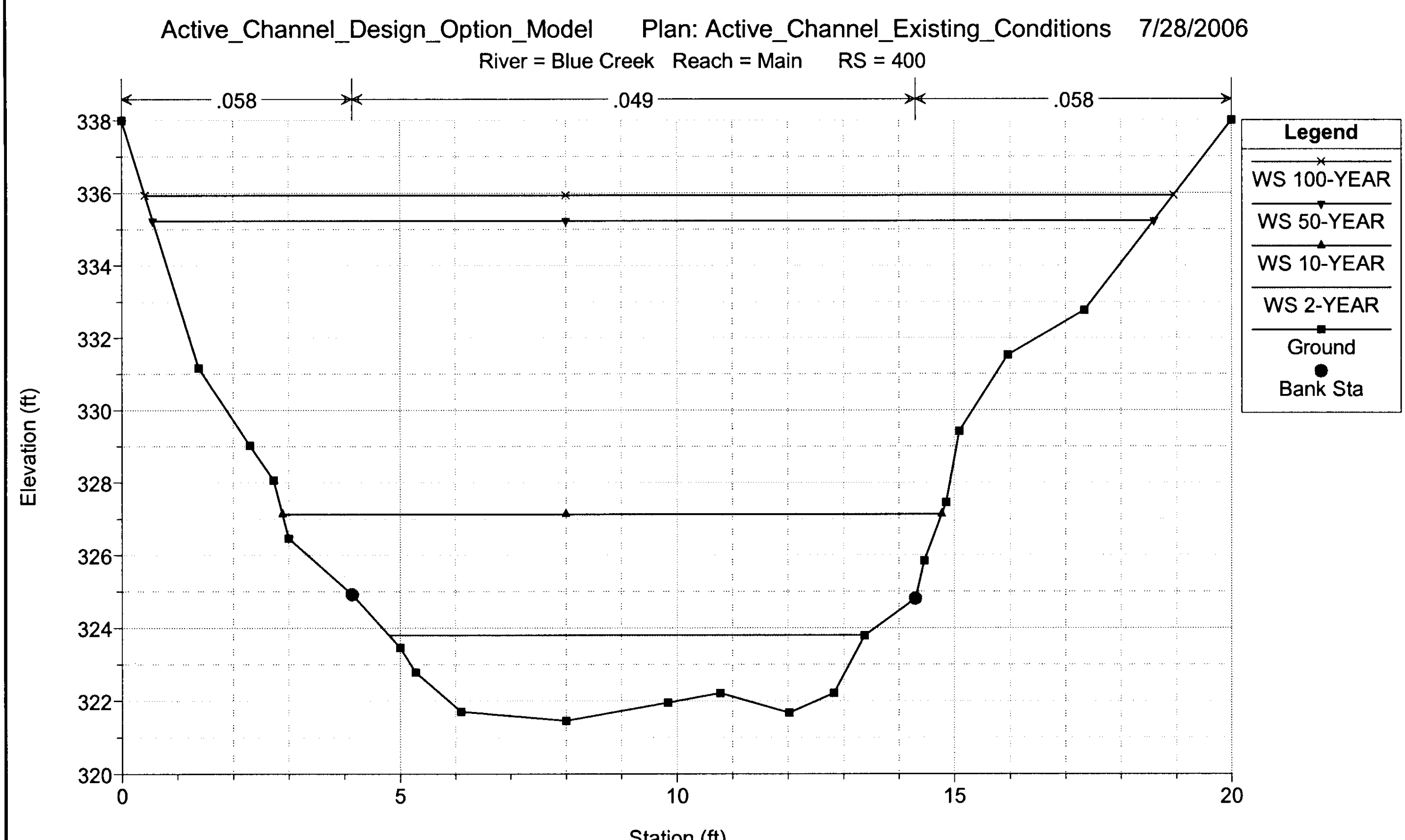


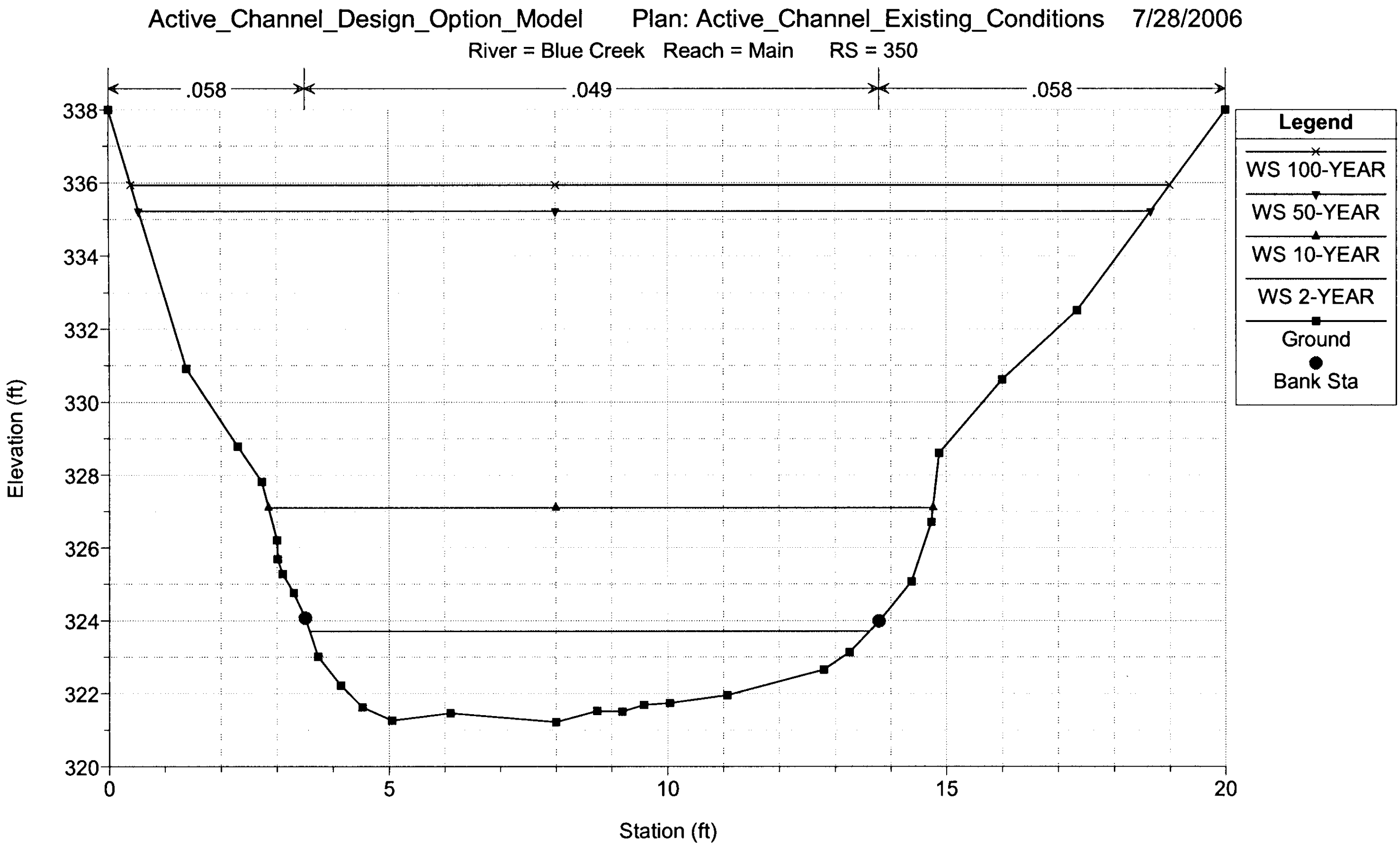
Active_Channel_Design_Option_Model Plan: Active_Channel_Existing_Conditions 7/28/2006
Blue Creek Main
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Elevation (ft)
338
336
334
332
330
328
326
324
322
320
318
100
175
230
269
299.5
350
400
500
600
800
0
200
400
600
800
Main Channel Distance (ft)


Active_Channel_Design_Option_Model Plan: Active_Channel_Existing_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 800
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Bank Sta
Elevation (ft)
Station (ft)
338
336
334
332
330
328
326
324
322
0
5
10
15
20

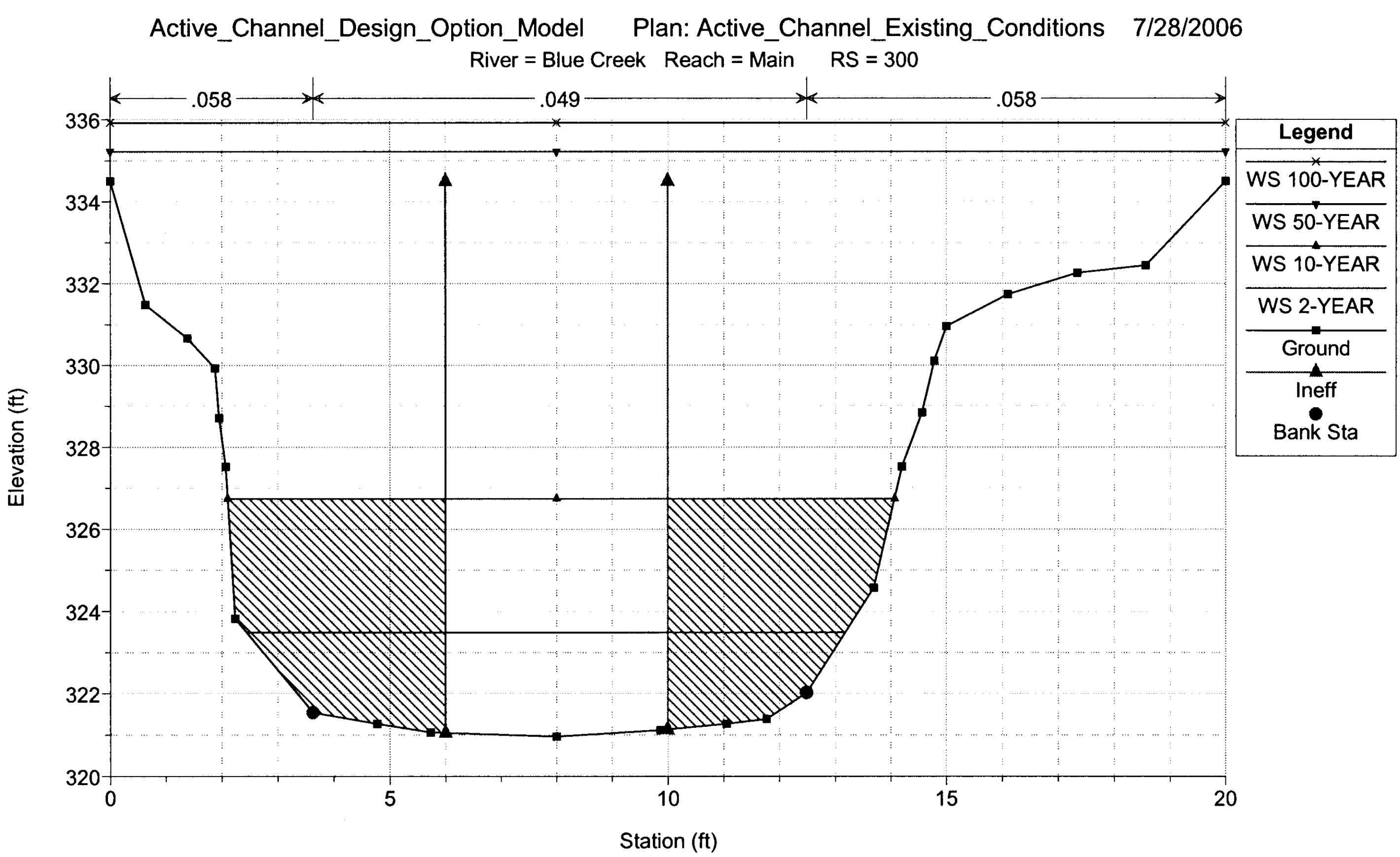

Active_Channel_Design_Option_Model Plan: Active_Channel_Existing_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 600
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Bank Sta
Elevation (ft)
Station (ft)
338
336
334
332
330
328
326
324
322
0
5
10
15
20


Active_Channel_Design_Option_Model
Plan: Active_Channel_Existing_Conditions
7/28/2006
River = Blue Creek
Reach = Main
RS = 500
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Bank Sta
Elevation (ft)
Station (ft)
338
336
334
332
330
328
326
324
322
320
0
5
10
15
20

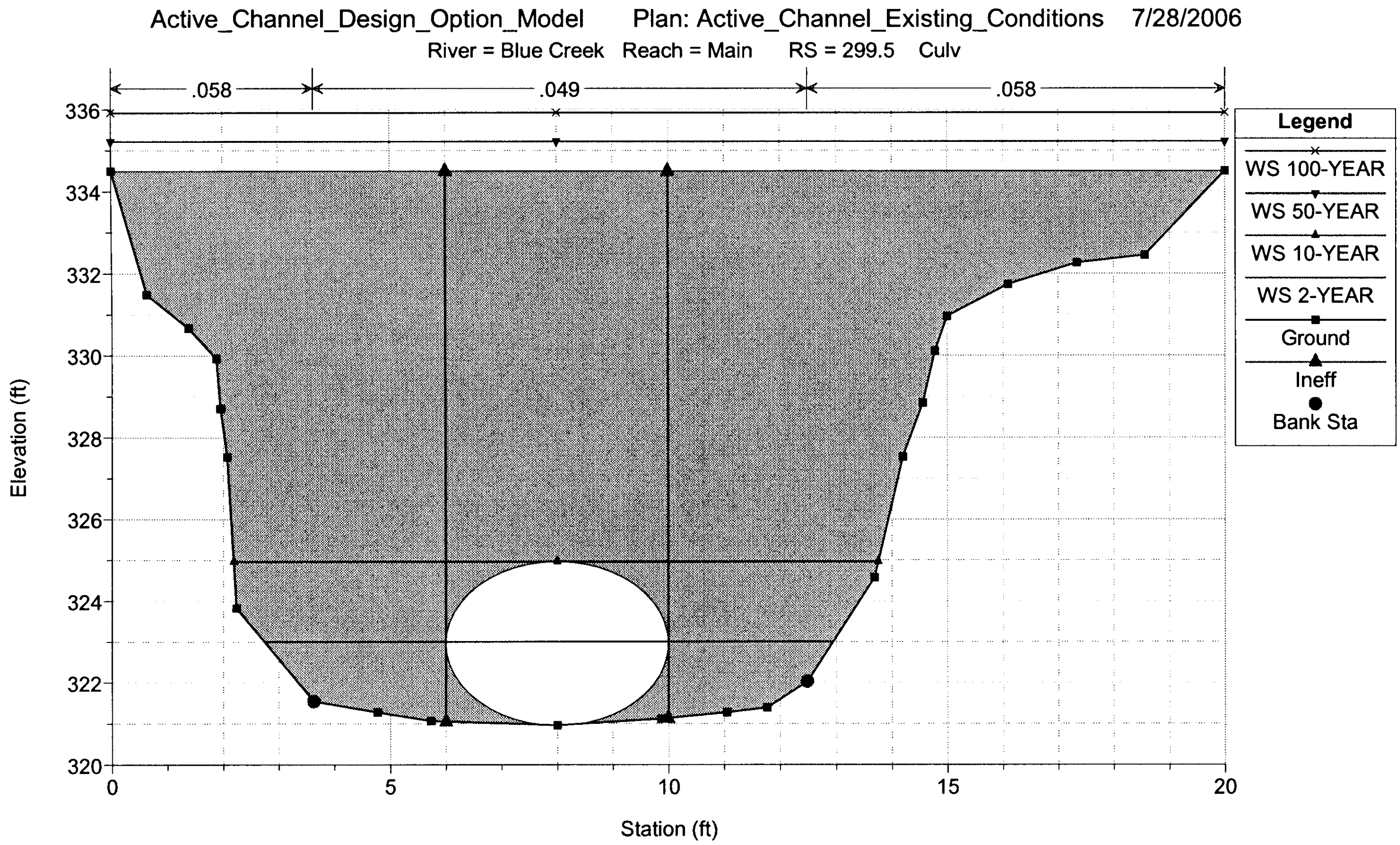

Active_Channel_Design_Option_Model
Plan: Active_Channel_Existing_Conditions
7/28/2006
River = Blue Creek
Reach = Main
RS = 400
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Bank Sta
Elevation (ft)
Station (ft)
338
336
334
332
330
328
326
324
322
320
0
5
10
15
20



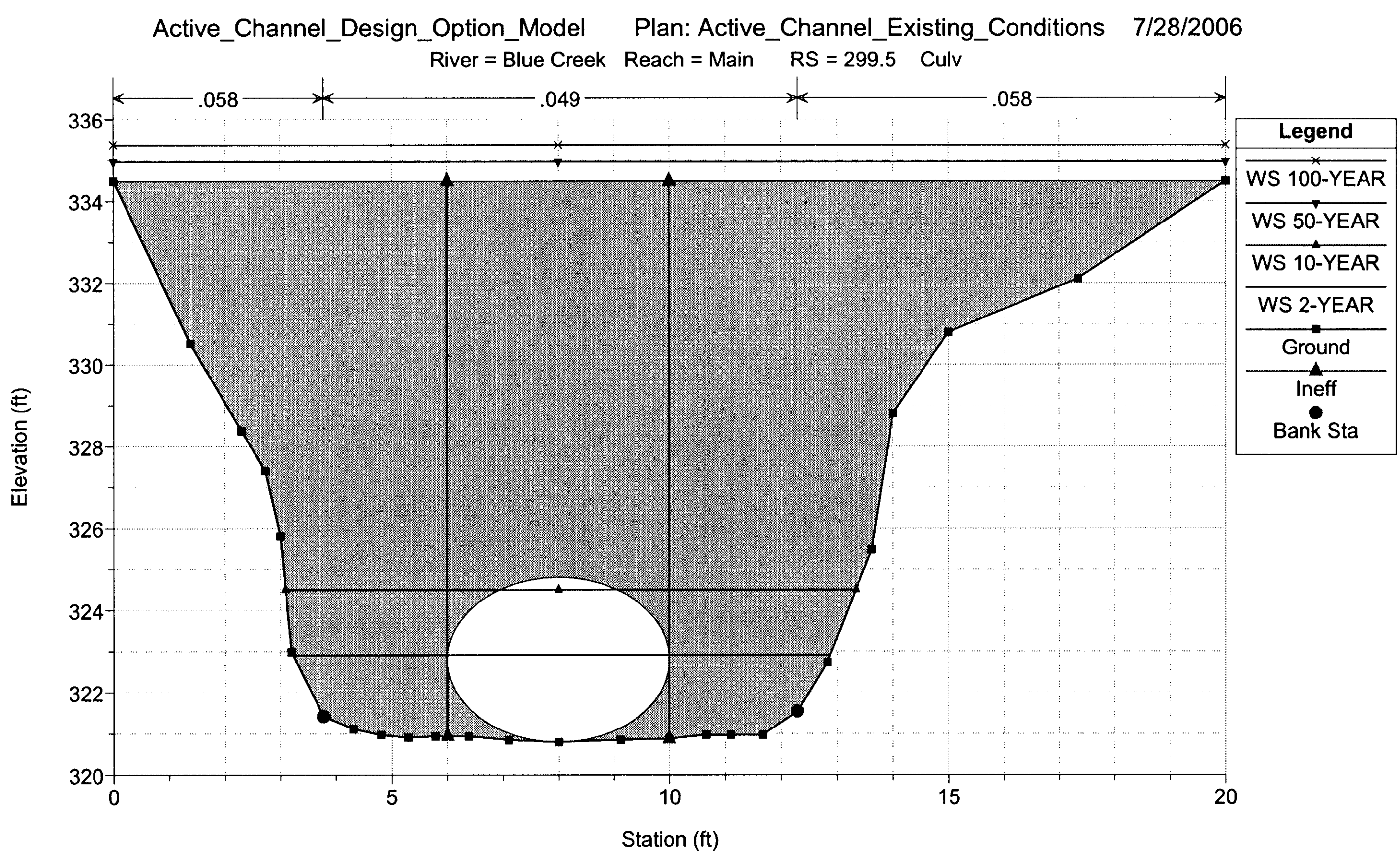
Active_Channel_Design_Option_Model Plan: Active_Channel_Existing_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 350
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Bank Sta
Elevation (ft)
338
336
334
332
330
328
326
324
322
320
0
5
10
15
20
Station (ft)



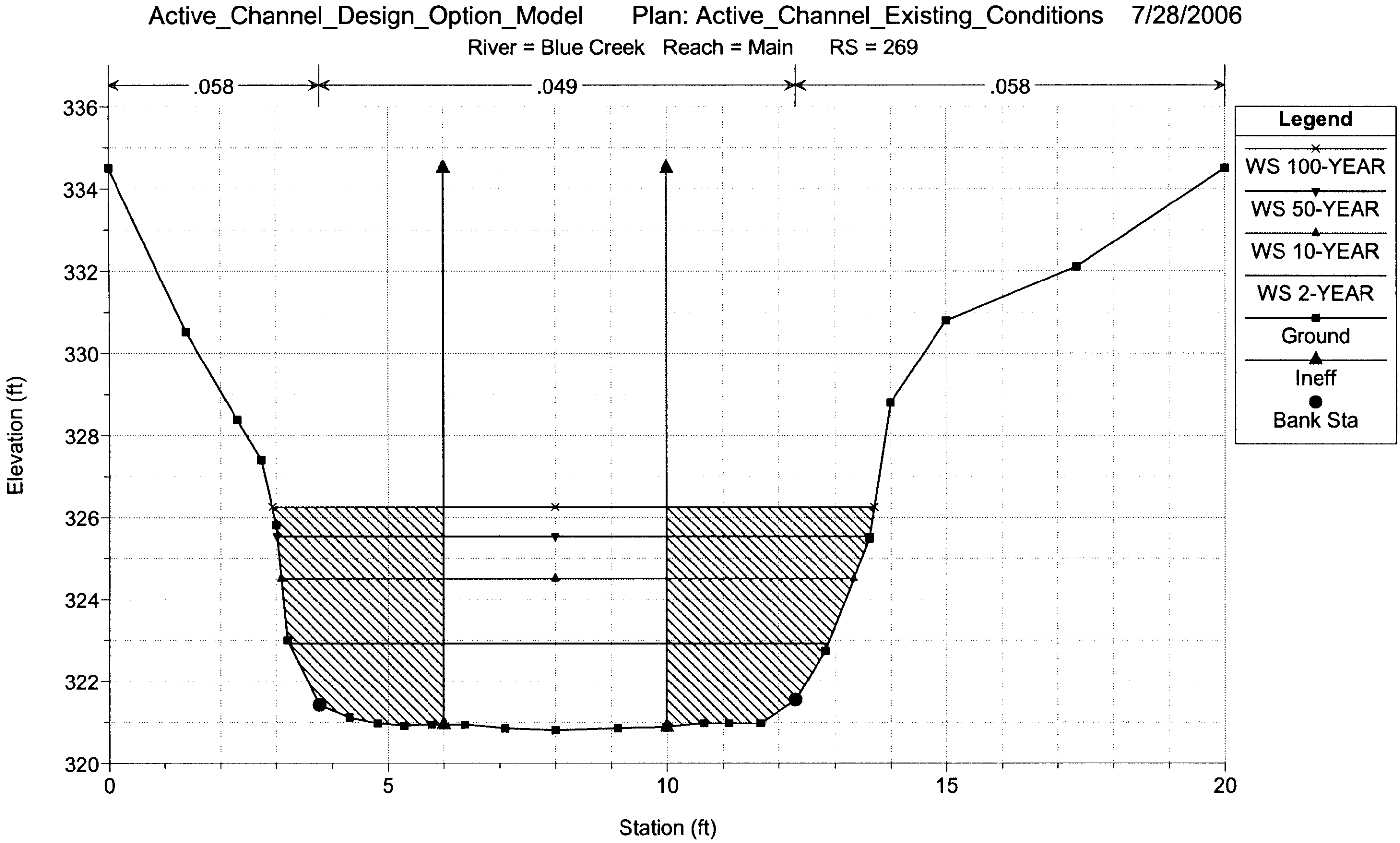
Active_Channel_Design_Option_Model Plan: Active_Channel_Existing_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 300
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Ineff
Bank Sta
Elevation (ft)
336
334
332
330
328
326
324
322
320
0
5
10
15
20
Station (ft)



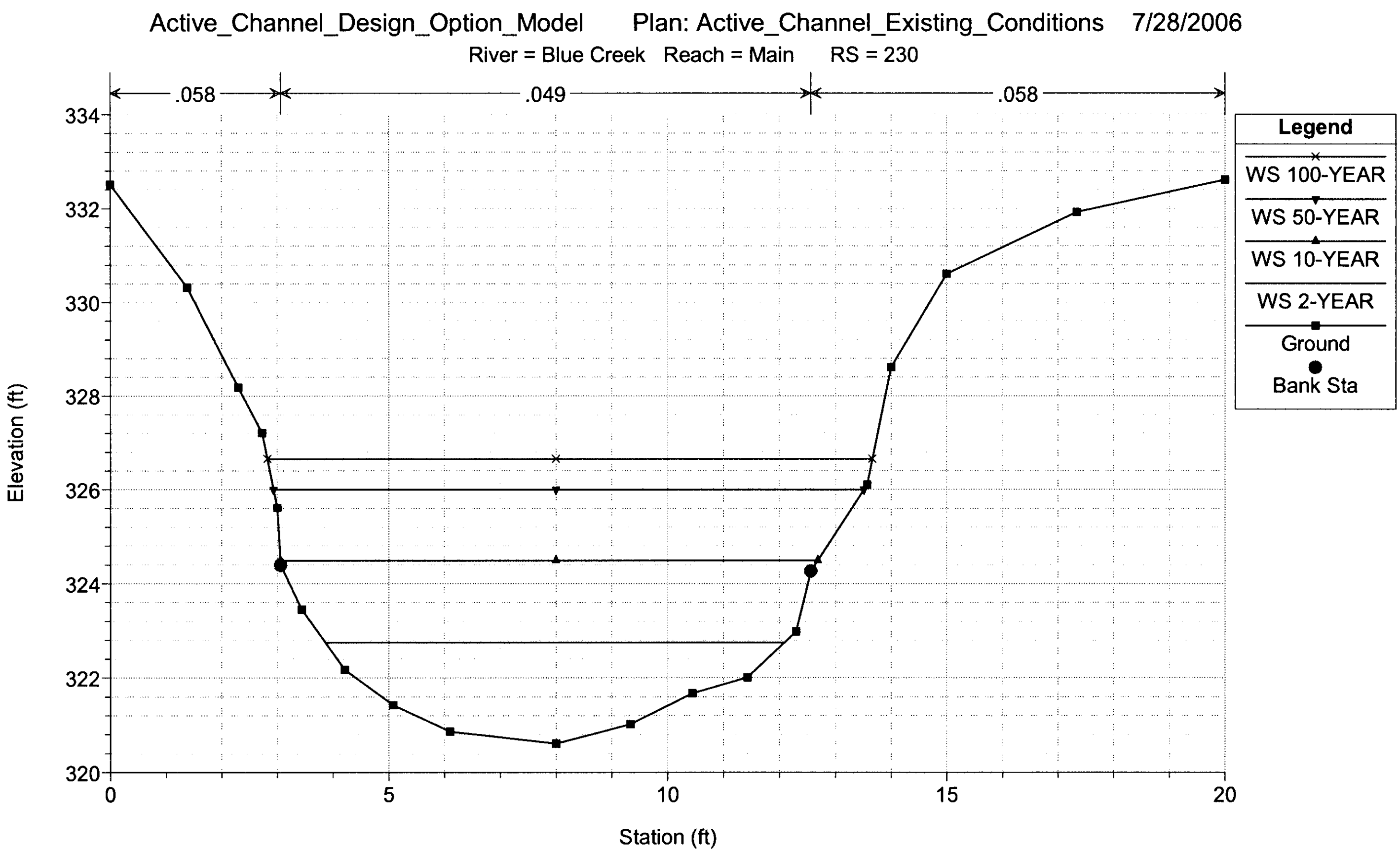
Active_Channel_Design_Option_Model Plan: Active_Channel_Existing_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 299.5 Culv
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Ineff
Bank Sta
Elevation (ft)
336
334
332
330
328
326
324
322
320
0
5
10
15
20
Station (ft)



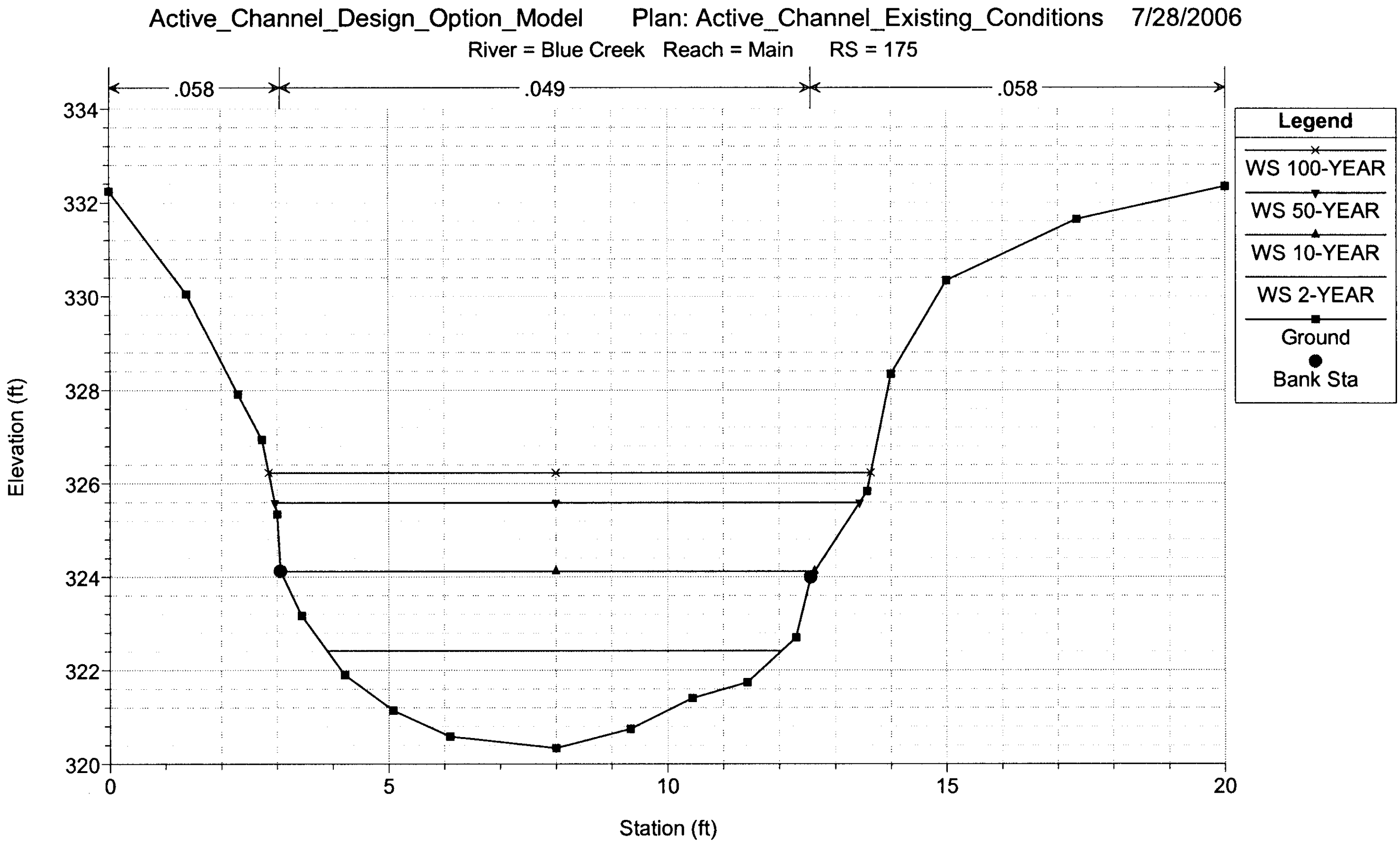
Active_Channel_Design_Option_Model Plan: Active_Channel_Existing_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 299.5 Culv
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Ineff
Bank Sta
Elevation (ft)
336
334
332
330
328
326
324
322
320
0
5
10
15
20
Station (ft)

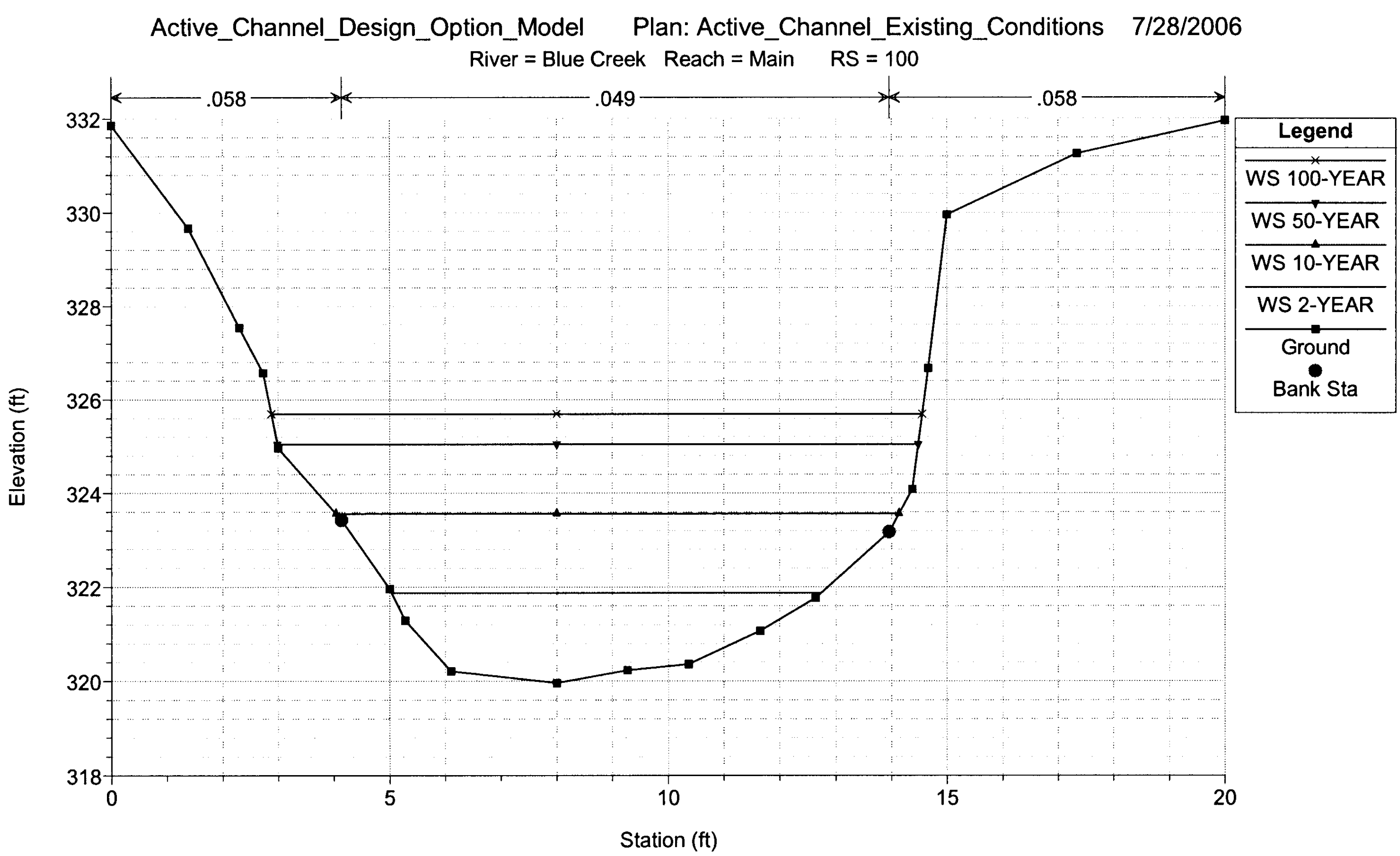


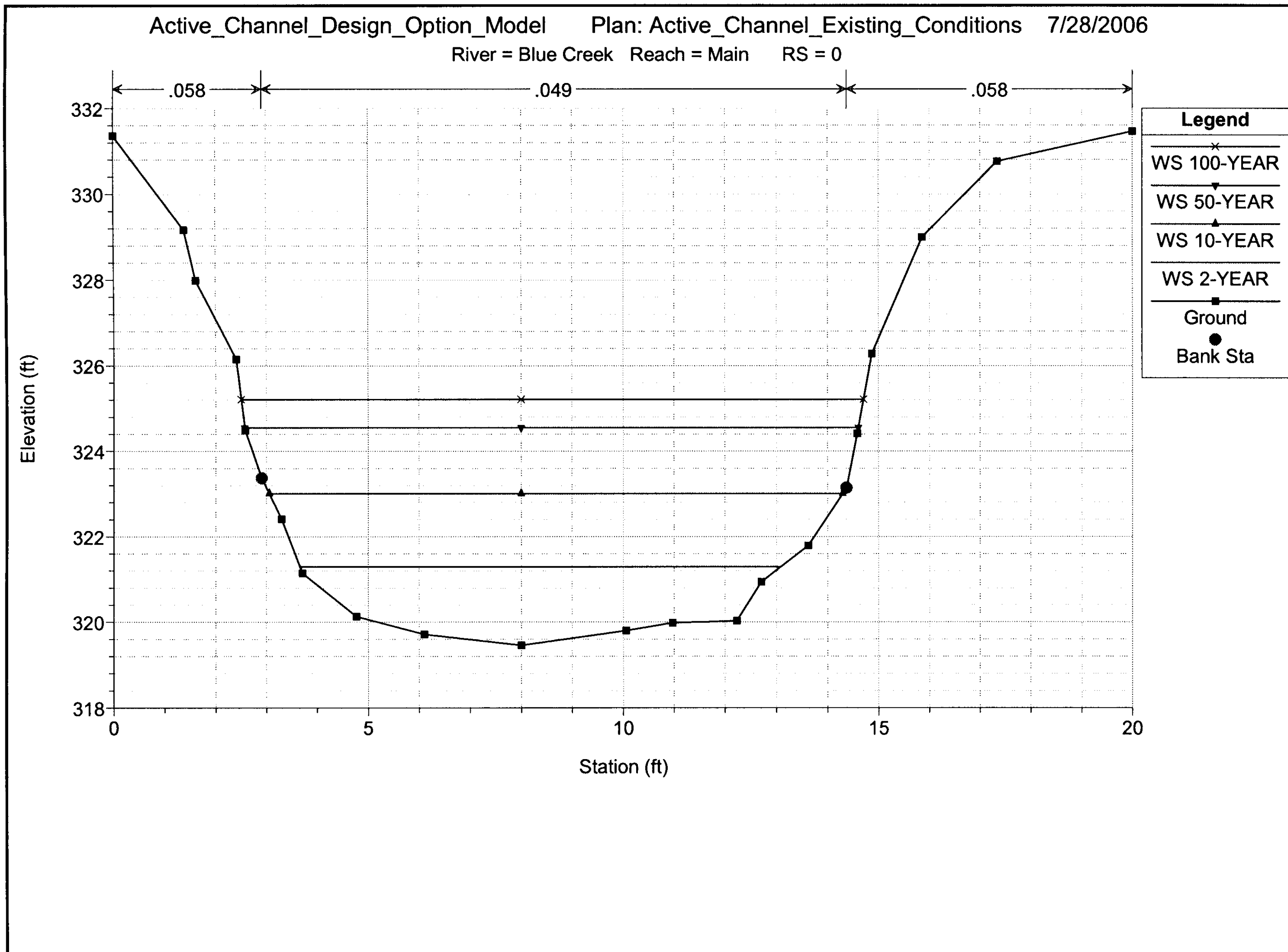
Active_Channel_Design_Option_Model Plan: Active_Channel_Existing_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 269
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
336
334
332
330
328
326
324
322
320
0
5
10
15
20



Active_Channel_Design_Option_Model Plan: Active_Channel_Existing_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 230
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Bank Sta
Elevation (ft)
Station (ft)
334
332
330
328
326
324
322
320
0
5
10
15
20


Active_Channel_Design_Option_Model Plan: Active_Channel_Existing_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 175
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Bank Sta
Elevation (ft)
334
332
330
328
326
324
322
320
0
5
10
15
20
Station (ft)


Active_Channel_Design_Option_Model Plan: Active_Channel_Existing_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 100
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Bank Sta
Elevation (ft)
332
330
328
326
324
322
320
318
0
5
10
15
20
Station (ft)



Active_Channel_Design_Option_Model Plan: Active_Channel_Existing_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 0
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Bank Sta
Elevation (ft)
332
330
328
326
324
322
320
318
0
5
10
15
20
Station (ft)

HEC-RAS Plan: Existing Conditions River: Blue Creek

River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Water Depth (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
0	2-YEAR	30	319.46	321.3	1.84	320.56	321.39	0.00501	2.38	12.59	9.43	0.36
0	10-YEAR	106	319.46	323.01	3.55	321.55	323.2	0.005003	3.48	30.43	11.24	0.37
0	50-YEAR	222	319.46	324.55	5.09	322.55	324.88	0.005004	4.61	48.45	12.03	0.4
0	100-YEAR	284	319.46	325.22	5.76	323	325.62	0.005005	5.09	56.5	12.2	0.41
100	2-YEAR	30	319.96	321.88	1.92		322.01	0.007684	2.89	10.38	7.71	0.44
100	10-YEAR	106	319.96	323.56	3.6		323.83	0.00751	4.17	25.45	10.1	0.46
100	50-YEAR	222	319.96	325.05	5.09		325.52	0.007114	5.5	41.64	11.49	0.48
100	100-YEAR	284	319.96	325.7	5.74		326.26	0.007048	6.04	49.14	11.67	0.49
175	2-YEAR	30	320.34	322.42	2.08		322.53	0.006232	2.68	11.21	8.15	0.4
175	10-YEAR	106	320.34	324.12	3.78		324.37	0.006817	4.01	26.47	9.57	0.42
175	50-YEAR	222	320.34	325.59	5.25		326.05	0.00723	5.47	41.18	10.48	0.47
175	100-YEAR	284	320.34	326.23	5.89		326.8	0.00736	6.06	48.02	10.79	0.48
230	2-YEAR	30	320.61	322.75	2.14		322.85	0.005507	2.56	11.7	8.23	0.38
230	10-YEAR	106	320.61	324.49	3.88		324.72	0.006061	3.87	27.42	9.63	0.4
230	50-YEAR	222	320.61	326	5.39		326.43	0.006497	5.3	42.62	10.58	0.45
230	100-YEAR	284	320.61	326.65	6.04	324.64	327.19	0.006646	5.88	49.63	10.84	0.46
269	2-YEAR	30	320.8	322.91	2.11	322.06	323.12	0.00554	3.65	8.23	9.66	0.45
269	10-YEAR	106	320.8	324.5	3.7	323.65	325.32	0.01029	7.27	14.57	10.25	0.67
269	50-YEAR	222	320.8	325.53	4.73	325.43	327.72	0.019696	11.88	18.69	10.61	0.97
269	100-YEAR	284	320.8	326.25	5.45	326.25	328.94	0.020024	13.17	21.56	10.78	1
299.5		Culvert										
300	2-YEAR	30	320.96	323.49	2.53	322.22	323.64	0.003021	3.04	9.87	10.74	0.34
300	10-YEAR	106	320.96	326.74	5.78	323.82	327.08	0.002292	4.63	22.87	11.96	0.34
300	50-YEAR	222	320.96	335.22	14.26	325.59	335.25	0.000084	1.58	189.64	20	0.07
300	100-YEAR	284	320.96	335.93	14.97	326.41	335.98	0.000115	1.91	203.75	20	0.09
350	2-YEAR	30	321.21	323.71	2.5		323.75	0.001604	1.6	18.73	10.04	0.21
350	10-YEAR	106	321.21	327.1	5.89		327.16	0.000634	1.96	56.63	11.91	0.15
350	50-YEAR	222	321.21	335.23	14.02		335.26	0.000107	1.51	177.93	18.12	0.07
350	100-YEAR	284	321.21	335.93	14.72		335.98	0.000146	1.82	190.93	18.6	0.09
400	2-YEAR	30	321.46	323.8	2.34		323.86	0.002694	1.94	15.46	8.59	0.25
400	10-YEAR	106	321.46	327.13	5.67		327.2	0.000969	2.17	50.6	11.89	0.17
400	50-YEAR	222	321.46	335.23	13.77		335.27	0.000135	1.57	169.54	18.03	0.08
400	100-YEAR	284	321.46	335.94	14.48		335.99	0.000183	1.89	182.52	18.54	0.09
500	2-YEAR	30	321.96	324.1	2.14		324.17	0.00353	2.15	13.96	8.63	0.3
500	10-YEAR	106	321.96	327.23	5.27		327.31	0.001227	2.34	46.71	11.87	0.2
500	50-YEAR	222	321.96	335.24	13.28		335.28	0.00015	1.63	161.92	17.85	0.08
500	100-YEAR	284	321.96	335.96	14		336.01	0.0002	1.96	174.86	18.41	0.1
600	2-YEAR	30	322.46	324.5	2.04		324.59	0.004884	2.38	12.63	8.24	0.34
600	10-YEAR	106	322.46	327.36	4.9		327.47	0.001804	2.61	40.95	10.71	0.23
600	50-YEAR	222	322.46	335.26	12.8		335.3	0.000184	1.73	150.47	17.63	0.09
600	100-YEAR	284	322.46	335.97	13.51		336.04	0.000244	2.07	163.36	18.25	0.1
800	2-YEAR	30	323.46	325.51	2.05	324.7	325.6	0.005295	2.39	12.54	8.58	0.35
800	10-YEAR	106	323.46	327.77	4.31	325.72	327.92	0.00278	3.21	35.49	11.29	0.29
800	50-YEAR	222	323.46	335.29	11.83	326.81	335.35	0.000257	2.04	136.92	17	0.11
800	100-YEAR	284	323.46	336.02	12.56	327.29	336.1	0.000335	2.42	149.59	17.81	0.12

Plan: Existing Blue Creek Main RS: 299.5 Culv Group: Culvert #1 Profile: 2-YEAR

Q Culv Group (cfs)	30.00	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	4.63
Q Barrel (cfs)	30.00	Culv Vel DS (ft/s)	4.45
E.G. US. (ft)	323.64	Culv Inv El Up (ft)	320.96
W.S. US. (ft)	323.49	Culv Inv El Dn (ft)	320.80
E.G. DS (ft)	323.12	Culv Frctn Ls (ft)	0.12
W.S. DS (ft)	322.91	Culv Exit Loss (ft)	0.10
Delta EG (ft)	0.52	Culv Entr Loss (ft)	0.30
Delta WS (ft)	0.58	Q Weir (cfs)	
E.G. IC (ft)	323.36	Weir Sta Lft (ft)	
E.G. OC (ft)	323.64	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	323.01	Weir Max Depth (ft)	
Culv WS Outlet (ft)	322.91	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	1.91	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	1.62	Min El Weir Flow (ft)	334.51

Plan: Existing Blue Creek Main RS: 299.5 Culv Group: Culvert #1 Profile: 10-YEAR

Q Culv Group (cfs)	106.00	Culv Full Len (ft)	1.95
# Barrels	1	Culv Vel US (ft/s)	8.44
Q Barrel (cfs)	106.00	Culv Vel DS (ft/s)	8.73
E.G. US. (ft)	327.08	Culv Inv El Up (ft)	320.96
W.S. US. (ft)	326.74	Culv Inv El Dn (ft)	320.80
E.G. DS (ft)	325.32	Culv Frctn Ls (ft)	0.40
W.S. DS (ft)	324.50	Culv Exit Loss (ft)	0.36
Delta EG (ft)	1.75	Culv Entr Loss (ft)	0.99
Delta WS (ft)	2.24	Q Weir (cfs)	
E.G. IC (ft)	327.04	Weir Sta Lft (ft)	
E.G. OC (ft)	327.08	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	324.96	Weir Max Depth (ft)	
Culv WS Outlet (ft)	324.50	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	4.00	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	3.12	Min El Weir Flow (ft)	334.51

Errors Warnings and Notes

Note:	The normal depth exceeds the height of the culvert. The program assumes that the normal
	depth is equal to the height of the culvert.

Plan: Existing Blue Creek Main RS: 299.5 Culv Group: Culvert #1 Profile: 50-YEAR

Q Culv Group (cfs)	186.22	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	14.82
Q Barrel (cfs)	186.22	Culv Vel DS (ft/s)	20.43
E.G. US. (ft)	335.25	Culv Inv El Up (ft)	320.96
W.S. US. (ft)	335.22	Culv Inv El Dn (ft)	320.80
E.G. DS (ft)	327.72	Culv Frctn Ls (ft)	2.18
W.S. DS (ft)	325.53	Culv Exit Loss (ft)	2.28
Delta EG (ft)	7.53	Culv Entr Loss (ft)	3.07
Delta WS (ft)	9.69	Q Weir (cfs)	35.78
E.G. IC (ft)	335.25	Weir Sta Lft (ft)	0.00
E.G. OC (ft)	333.33	Weir Sta Rgt (ft)	20.00
Culvert Control	Inlet	Weir Submerg	0.00
Culv WS Inlet (ft)	324.96	Weir Max Depth (ft)	0.78
Culv WS Outlet (ft)	323.52	Weir Avg Depth (ft)	0.78
Culv Nml Depth (ft)	4.00	Weir Flow Area (sq ft)	15.59
Culv Crt Depth (ft)	4.00	Min El Weir Flow (ft)	334.51

Errors Warnings and Notes

Warning:	The flow through the culvert is supercritical. However, since there is flow over the road (weir
	flow), the program cannot determine if the downstream cross section should be subcritical or
	supercritical. The program used the downstream subcritical answer, even though it may not be
	valid.
Warning:	During the supercritical analysis, the program could not converge on a supercritical answer in
	the downstream cross section. The program used the solution with the least error.
Note:	The normal depth exceeds the height of the culvert. The program assumes that the normal
	depth is equal to the height of the culvert.
Note:	Culvert critical depth exceeds the height of the culvert.
Note:	The flow in the culvert is entirely supercritical.

Plan: Existing Blue Creek Main RS: 299.5 Culv Group: Culvert #1 Profile: 100-YEAR

Q Culv Group (cfs)	191.68	Culv Full Len (ft)	30.00
# Barrels	1	Culv Vel US (ft/s)	15.25
Q Barrel (cfs)	191.68	Culv Vel DS (ft/s)	15.25
E.G. US. (ft)	335.98	Culv Inv El Up (ft)	320.96
W.S. US. (ft)	335.93	Culv Inv El Dn (ft)	320.80
E.G. DS (ft)	328.94	Culv Frctn Ls (ft)	2.86
W.S. DS (ft)	326.25	Culv Exit Loss (ft)	0.92
Delta EG (ft)	7.03	Culv Entr Loss (ft)	3.25
Delta WS (ft)	9.68	Q Weir (cfs)	92.32
E.G. IC (ft)	335.98	Weir Sta Lft (ft)	0.00
E.G. OC (ft)	335.80	Weir Sta Rgt (ft)	20.00
Culvert Control	Inlet	Weir Submerg	0.00
Culv WS Inlet (ft)	324.96	Weir Max Depth (ft)	1.47
Culv WS Outlet (ft)	324.80	Weir Avg Depth (ft)	1.47
Culv Nml Depth (ft)	4.00	Weir Flow Area (sq ft)	29.32
Culv Crt Depth (ft)	4.00	Min El Weir Flow (ft)	334.51

Errors Warnings and Notes

Note:	The normal depth exceeds the height of the culvert. The program assumes that the normal
	depth is equal to the height of the culvert.
Note:	Culvert critical depth exceeds the height of the culvert.
Note:	During the supercritical calculations a hydraulic jump occurred inside of the culvert.

Form 6A - Active Channel Design Option

Form 6A provides guidance to correctly select the active channel width while satisfying traffic safety, hydraulic impacts and scour concerns.

For this particular example, the average active channel width was measured at 5.3 feet. The culvert width is required to be 1.5 times the average active channel width; therefore, the proposed culvert width is 8 feet in diameter. By placing the culvert at the required 0% slope, the culvert inlet and outlet was embedded meeting the required embedment depth requirements. Although no specific species, depth, or velocity criteria had to be met, hydraulic analyses for hydraulic impacts and scour were satisfied.

FISH PASSAGE: ACTIVE CHANNEL DESIGN OPTION			FORM 6A
Project Information Route 888 4-Lane	Computed: EKB		Date: 5/6/06
	Checked: JJL		Date: 5/8/06
Stream Name: Blue Creek	County: Sacramento	Route: 888	Postmile: 67.2

Hydrology Results - Peak Discharge Values

50% Annual Probability (2-Year Flood Event)	30 cfs	10% Annual Probability (10-Year Flood Event)	106 cfs
2% Annual Probability (50-Year Flood Event)	222 cfs	1% Annual Probability (100-Year Flood Event)	284 cfs

Establish Culvert Setting and Dimensions

Culvert Width - The minimum culvert width shall be equal to, or greater than, 1.5 times the average active channel width.

Average Active Channel Width = 5.3 ft	Average Active Channel Width 5.3 X 1.5 = 7.95 ft	Culvert Width = 8.0 ft

Culvert Length - Must be less than 100 feet.

Culvert Length = 68 ft

Culvert Embedment - The bottom of the culvert shall be buried into the streambed not less than 20% of the culvert height at the outlet and not more than 40% of the culvert height at the inlet.

Upstream Embedment =	1.94 ft	(≤ then 40% of culvert rise) 24% of Culvert rise
Downstream Embedment =	1.60 ft	(≥ 20% of culvert rise) 20% of Culvert rise

Culvert Slope - The culvert shall be placed level (0% slope).

Upstream invert elevation = 319.02 ft	Downstream invert elevation = 319.02 ft

Summarize Proposed Culvert Physical Characterstics

Inlet Characteristics

Inlet Type	☐ Projecting	☒ Headwall	☐ Wingwall
	☐ Flared end section	☐ Segment connection	☐ Skew Angle: °

Barrel Characteristics

Diameter: . 96 in	Fill height above culvert: ~7.5 ft
Height/Rise: — ft	Length: 68 ft

FISH PASSAGE: ACTIVE CHANNEL DESIGN OPTION — FORM 6A

Width/Span:	— ft	Number of barrels:	1
Culvert Type	☐ Arch ☐ Pipe-Arch	☐ Box ☐ Elliptical	☒ Circular
Culvert Material	☐ HDPE ☐ Spiral Rib / Corrugated Metal Pipe	☐ Steel Plate Pipe	☒ Concrete Pipe
Horizontal alignment breaks:	NONE ft	Vertical alignment breaks:	NONE ft

Outlet Characteristics

Outlet Type	☐ Projecting ☐ Flared end section	☒ Headwall ☐ Segment connection	☐ Wingwall Skew Angle: °

Summarize Proposed Bridge Physical Characterstics N/A

Bridge Physical Characteristics

Elevation of high chord (top of road):	ft	Elevation of low chord:	ft
Channel Lining	☐ No lining ☐ Concrete	☐ Rock	Channel Lining
Skew Angle:	°	Bridge width (length):	ft

Pier Characteristics (if applicable) ☐

Number of Piers:	ft	Upstream cross-section starting station:	ft
Pier Width:	ft	Downstream cross-section starting station:	ft
Pier Centerline Spacing:	ft	Skew angle:	°

Pier Shape	☐ Square nose and tail ☐ Twin-cylinder piers with connecting diaphragm	☐ Semi-circular nose and tail ☐ Twin-cylinder piers without connecting diaphragm	☐ 90° triangular nose and tail ☐ Ten pile trestle bent

Maximum Allowable Inlet Water Surface Elevation

Culvert

A culvert is required to pass the 10-year peak discharge without causing pressure flow in the culvert,	Allowable WSEL: 327.02 ft
And shall not be greater than 50% of the culvert height or diameter above the top of the culvert inlet for the 100-Year peak flood.	Allowable WSEL: 331.02 ft

FISH PASSAGE: ACTIVE CHANNEL DESIGN OPTION — FORM 6A

Bridge N/A

A bridge is required to pass the 50-year peak discharge with freeboard, vertical clearance between the lowest structural member and the water surface elevation,	Allowable WSEL: ft
While passing the 100-year peak or design discharge under low chord of bridge.	Allowable WSEL: ft

Establish Allowable Hydraulic Impacts

Is the crossing located within a floodplain as designated by the Federal Emergency Management Agency or another responsible state or local agency?
☐ Yes ☒ No

If yes, establish allowable hydraulic impacts and hydraulic design requirements with the appropriate agency. Attach results.

Will the project result in the increase capacity of an existing crossing? ☐ Yes ☒ No

If yes, will it significantly increase downstream peak flows due to the reduced upstream attenuation? ☐ Yes ☒ No

If yes, consult District Hydraulics. Further analysis may be needed.

Will the project result in a reduction in flow area for the 100-year peak discharge? ☐ Yes ☒ No

If yes, establish the allowable increase in upstream water surface elevation and establish how far upstream the increased water surface may extend.

Develop and run Hydraulic Models to compute water surface elevations, flow depths, and channel velocities for the 2-, 10-, 50-, and 100-year peak or design discharges reflecting existing and project conditions. ☒ Yes ☐ No

Evaluate computed water surface elevations, flow depths, and channel velocities. ☒ Yes ☐ No

Water surface elevation at inlet for the 10-year peak discharge: 327.02 **ft**

Does the water surface elevation exceed the allowable elevation? ☐ Yes ☒ No

If yes, modify design to comply and rerun hydraulic analyses to verfiy.

Maximum Culvert and Channel velocities at inlet and outlet transition for the peak or design discharge: 100-Yr

Range of velocities for Inlet transition:	5.09	ft/s	to	—	ft/s
Range of velocities for Culvert portion:	5.45	ft/s	to	5.60	ft/s
Range of velocities for Outlet Transition:	6.02	ft/s	to	—	ft/s

Do the velocities exceed the permissible scour velocities? ☐ Yes ☒ No

If yes, revise design to reduce velocities and rerun hydraulic analyses to verfiy, or design erosion protection.

Comparison between existing and project future condition water surface elevations for the 10-Year and 100-Year peak flow:

Cross-Section	10-Yr WSEL	10-Yr WSEL	Difference	100-Year WSEL	100-Year WSEL	Difference
	Existing	Future	(ft)	Existing	Future	(ft)

FISH PASSAGE: ACTIVE CHANNEL DESIGN OPTION						FORM 6A
	Conditions (ft)	Conditions (ft)		Conditions (ft)	Conditions (ft)	
1 230/175	324.49	324.12	-0.37	326.65	326.23	-0.42
2 269/231	324.50	324.40	-0.10	326.25	326.52	+0.27
3 300/300	326.74	324.75	-1.99	335.93	327.94	-7.99
4 350/350	327.10	324.90	-2.20	335.93	328.18	-7.75

If WSELs increase, does the increase exceed the maximum elevation? ☐ Yes ☒ No — Maximum elevation: ft

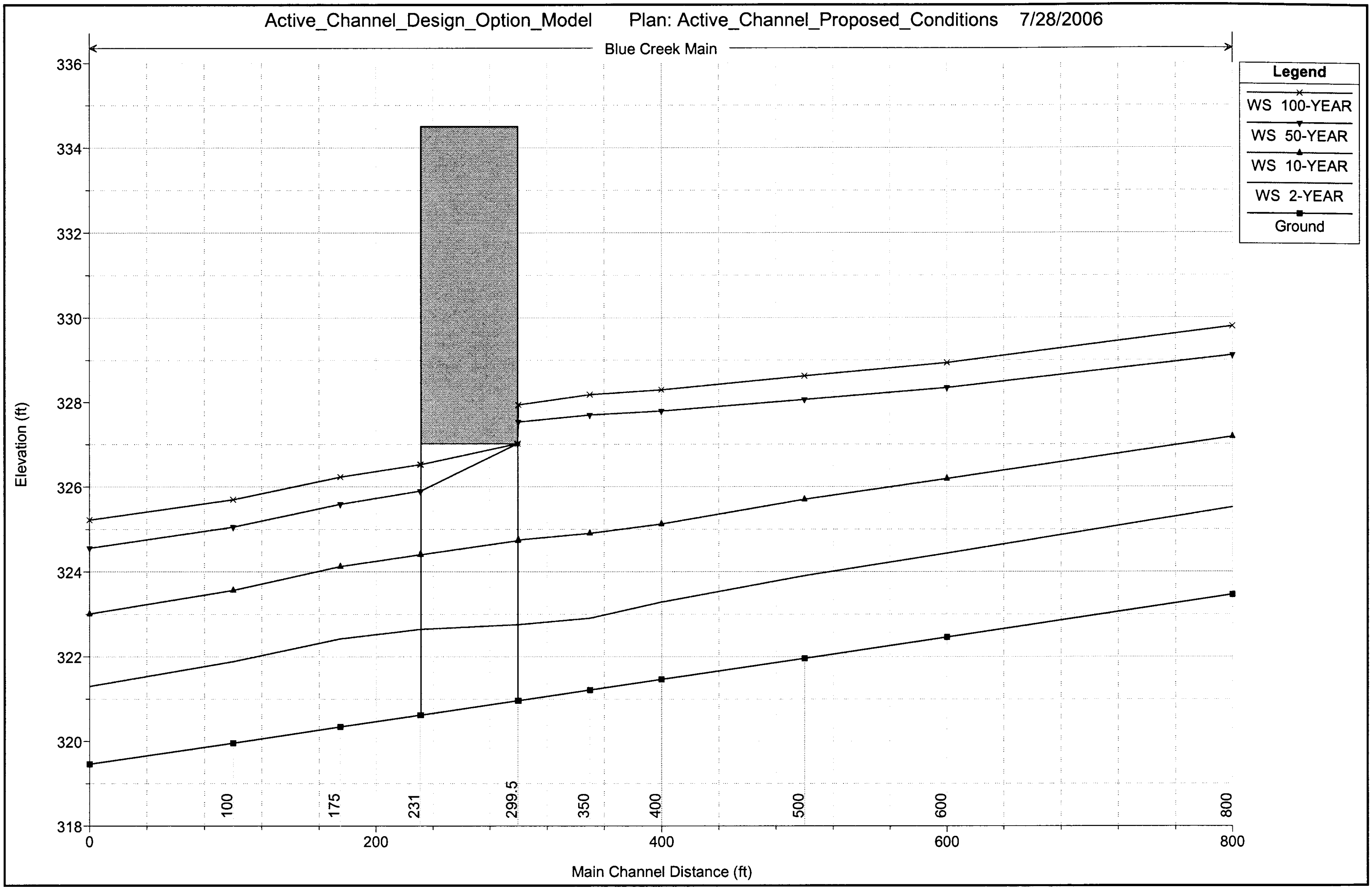
If yes, revise the design and rerun hydraulic analyses to verify.

If WSELs decrease, does it appear that the attenuation of peak flow will significally change? ☐ Yes ☒ No

If yes, evaluate to determine if downstream hydraulic impacts are significant and modify design as appropriate.

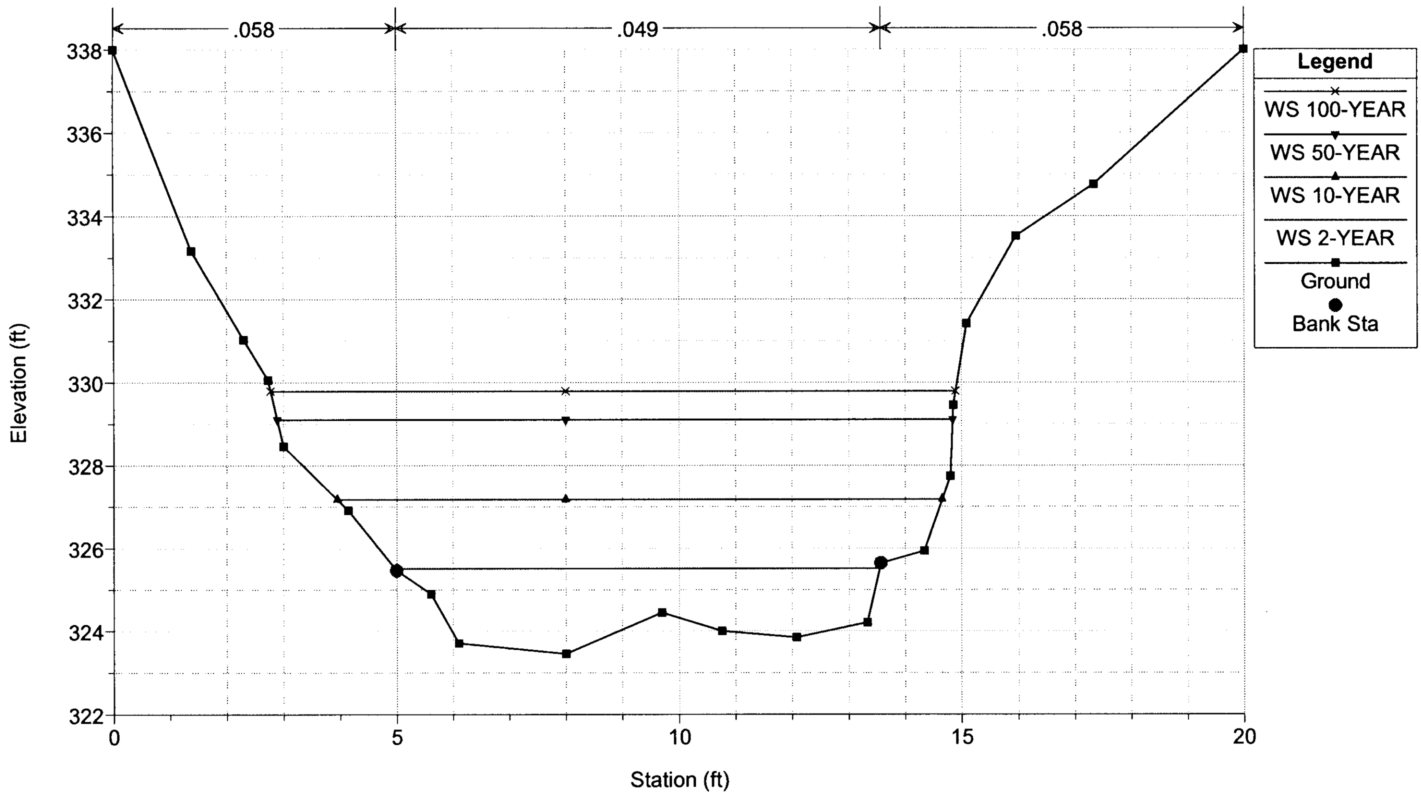
Proposed Plan and Profile Drawing Attached ☒ Yes ☐ No

Hydraulic Analysis Index Sheet Attached ☒ Yes ☐ No


Active_Channel_Design_Option_Model Plan: Active_Channel_Proposed_Conditions 7/28/2006
Blue Creek Main
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Elevation (ft)
336
334
332
330
328
326
324
322
320
318
100
175
231
299.5
350
400
500
600
800
0
200
400
600
800
Main Channel Distance (ft)

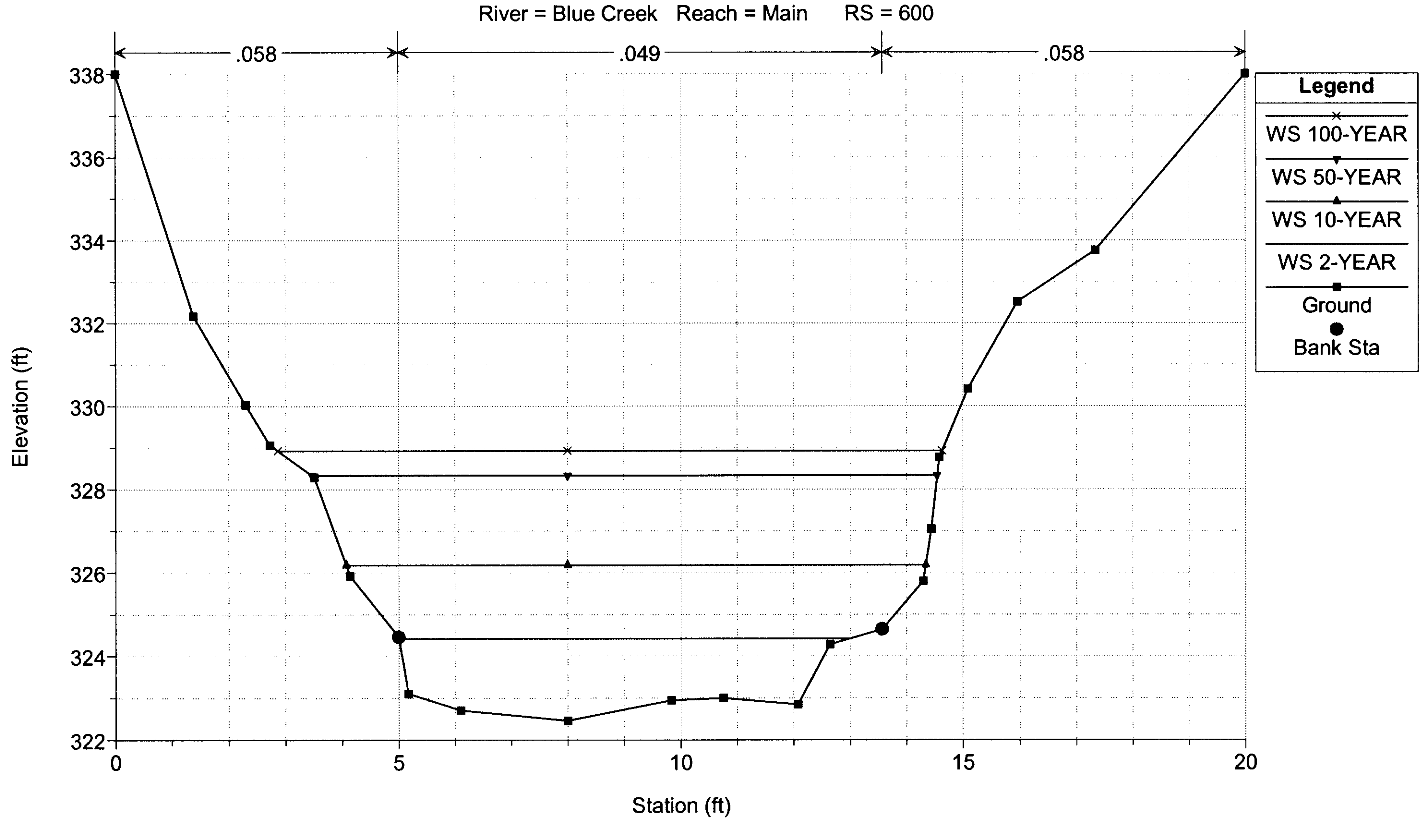
Active_Channel_Design_Option_Model   Plan: Active_Channel_Proposed_Conditions   7/28/2006

River = Blue Creek Reach = Main RS = 800



Active_Channel_Design_Option_Model   Plan: Active_Channel_Proposed_Conditions   7/28/2006

River = Blue Creek Reach = Main RS = 600



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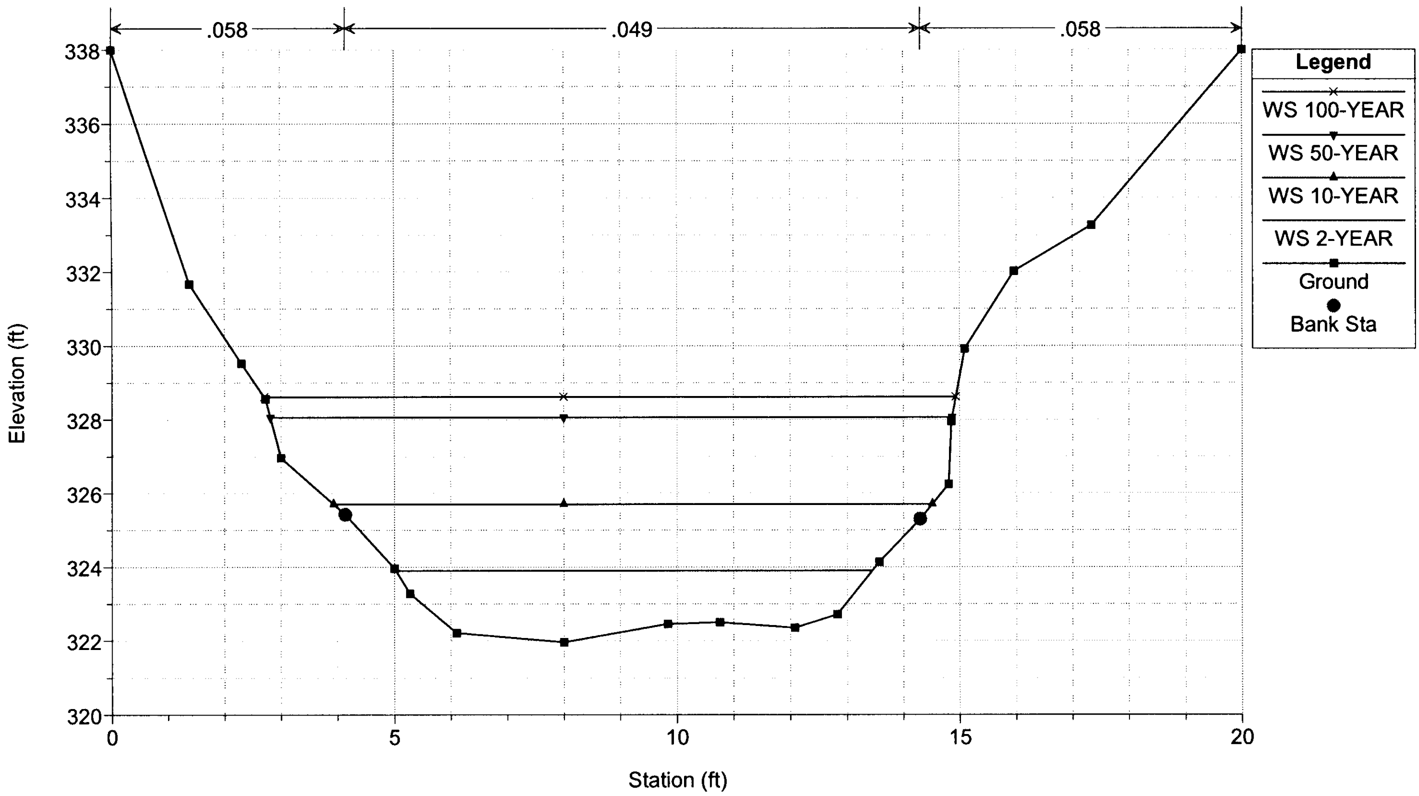
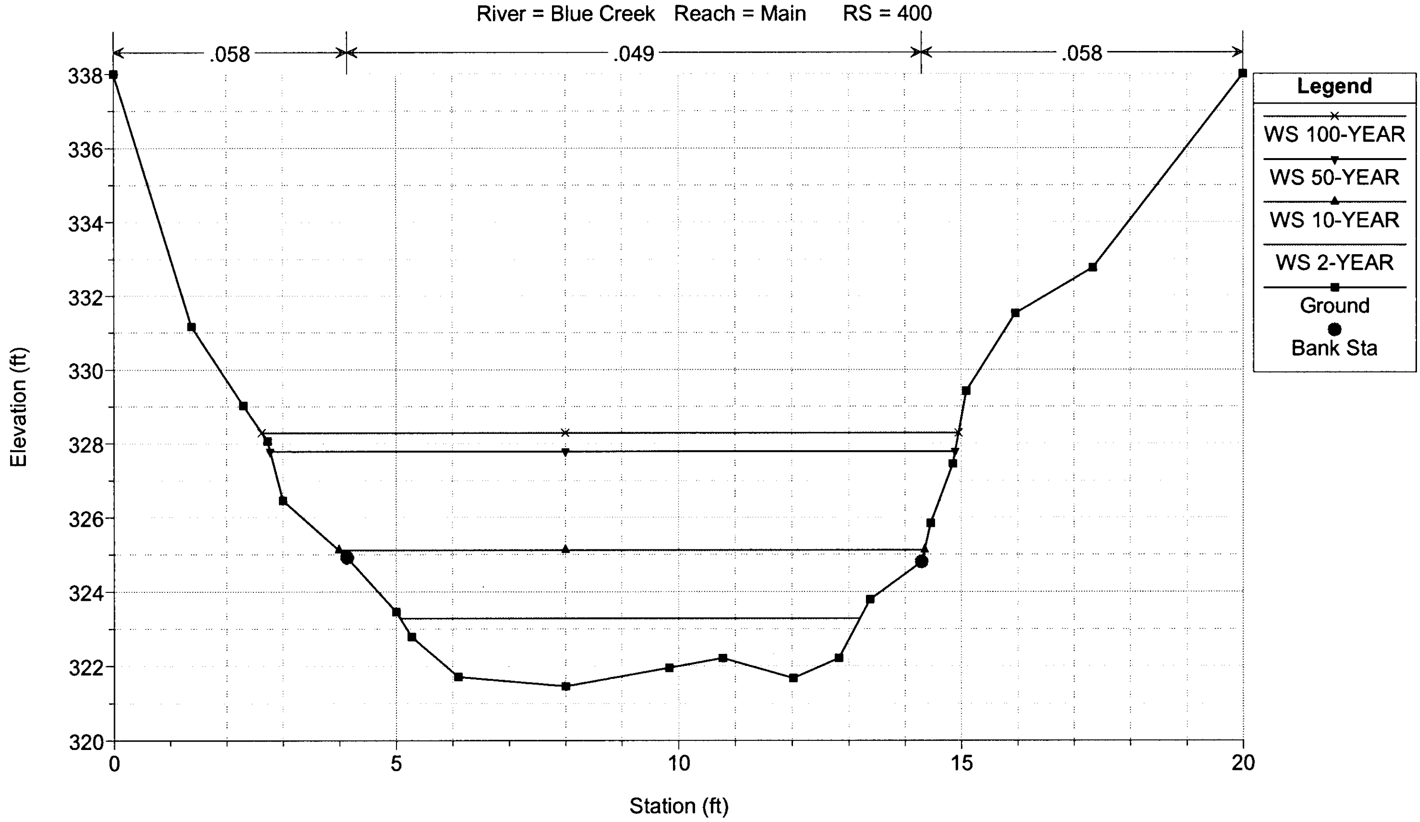
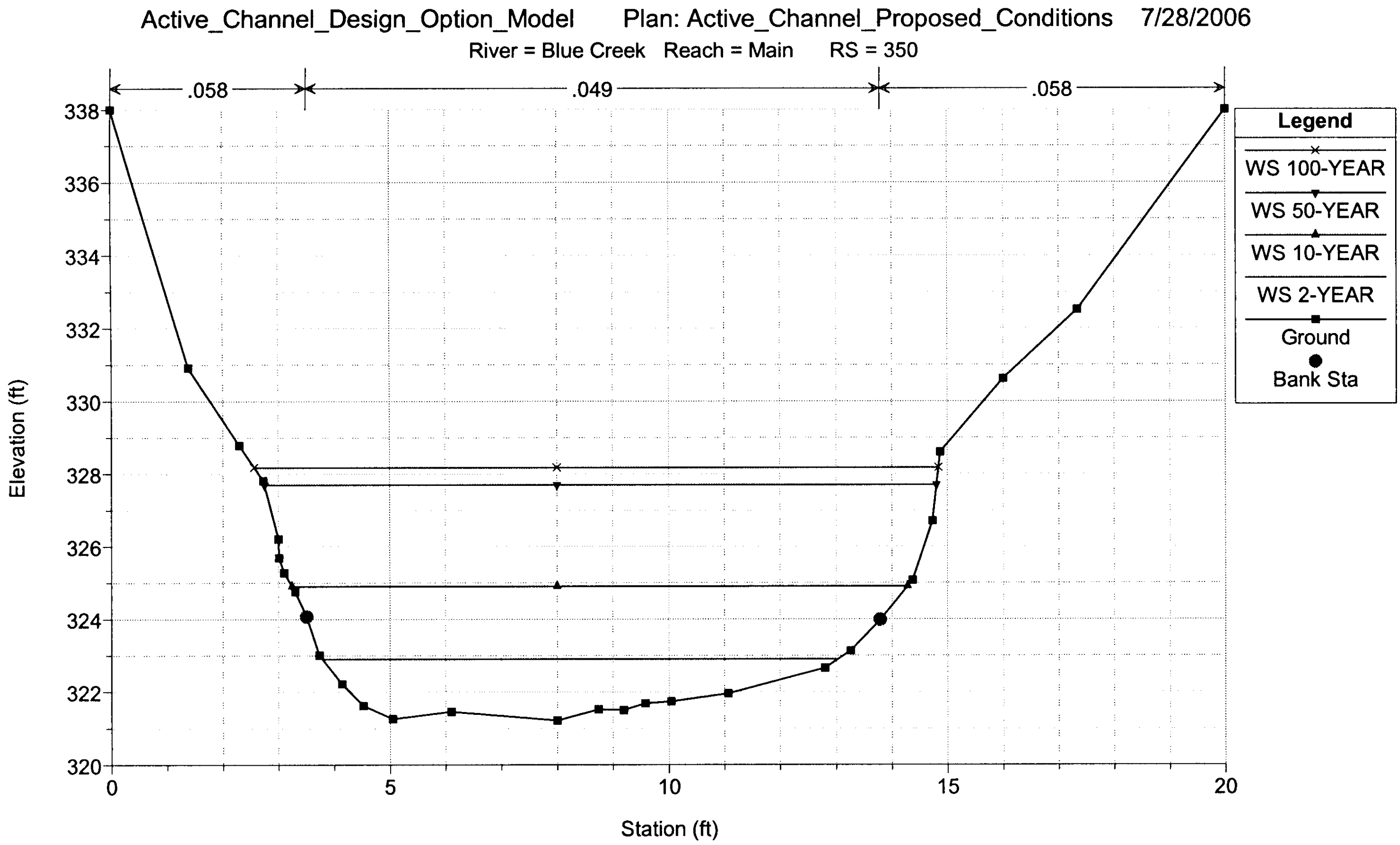
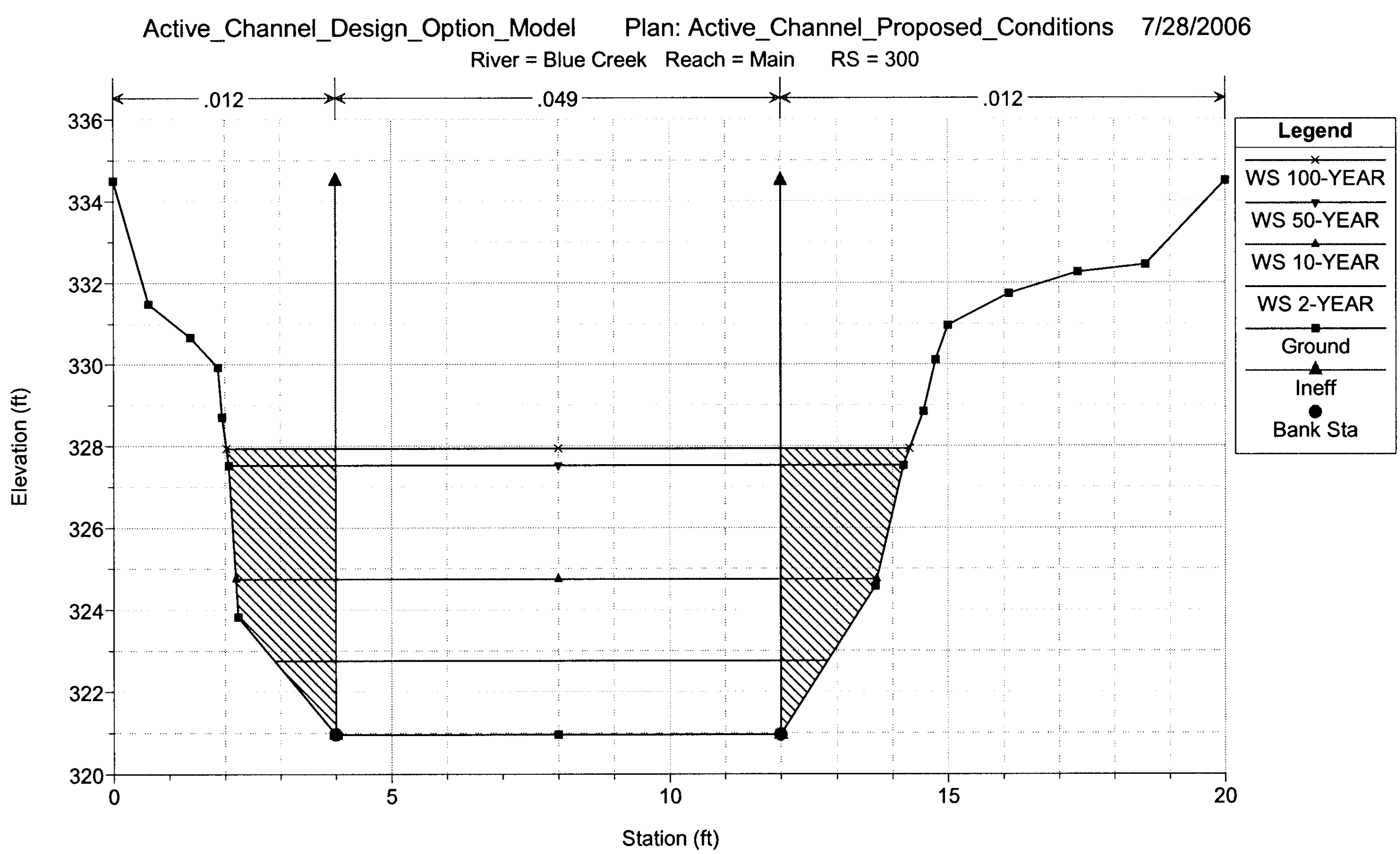
River = Blue Creek Reach = Main RS = 500

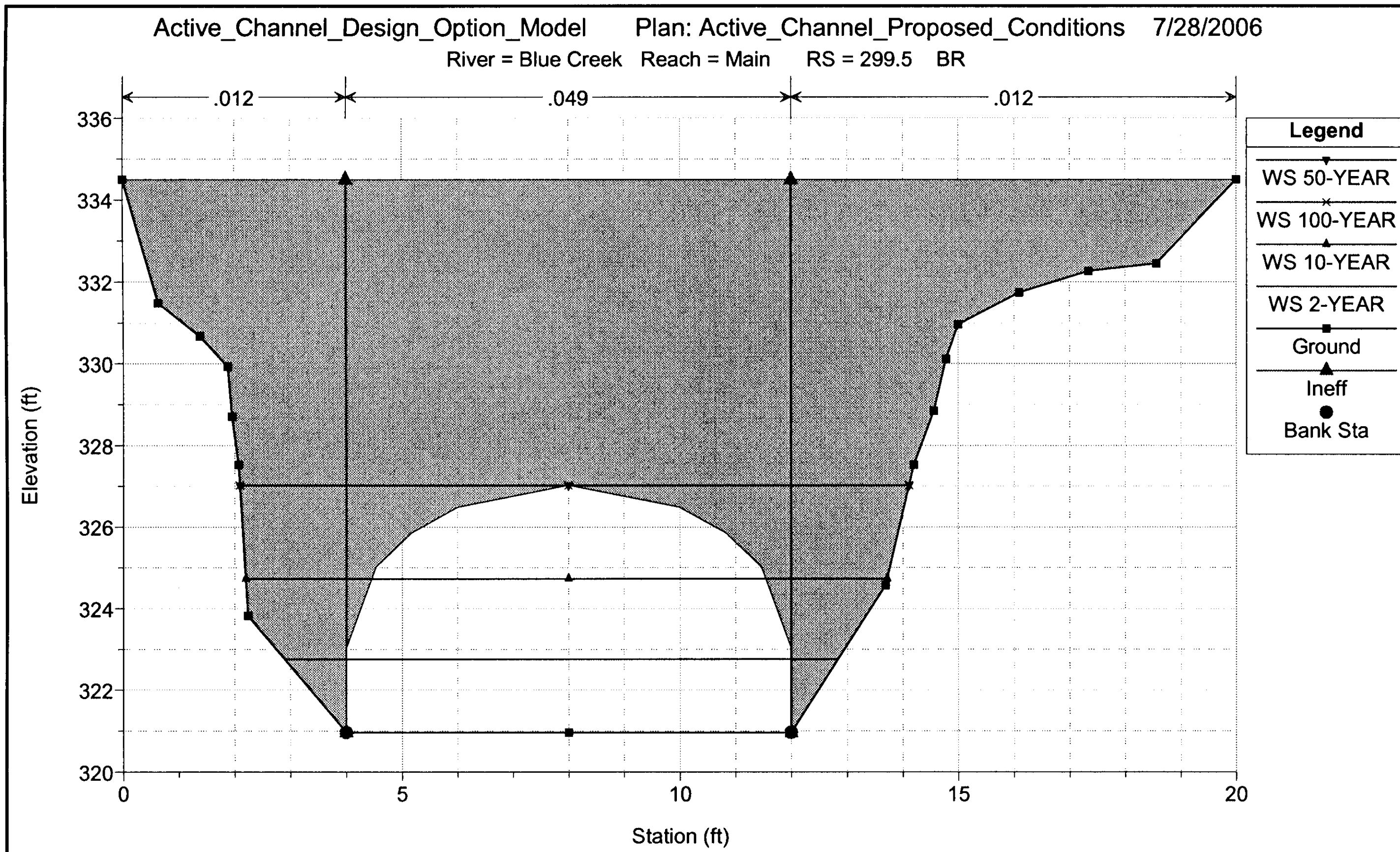


Active_Channel_Design_Option_Model Plan: Active_Channel_Proposed_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 400

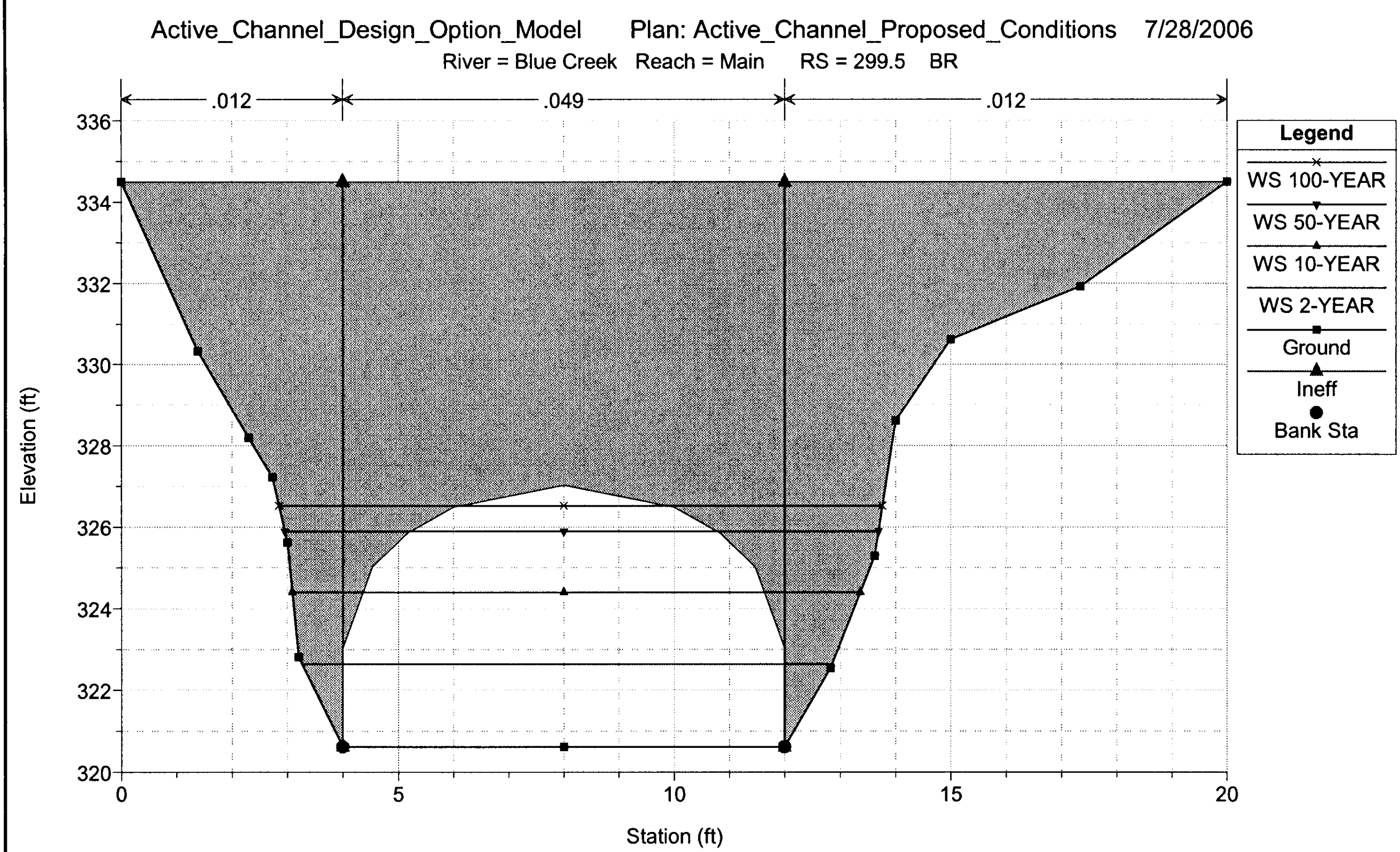



Active_Channel_Design_Option_Model Plan: Active_Channel_Proposed_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 350
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Bank Sta
Elevation (ft)
Station (ft)
338
336
334
332
330
328
326
324
322
320
0
5
10
15
20

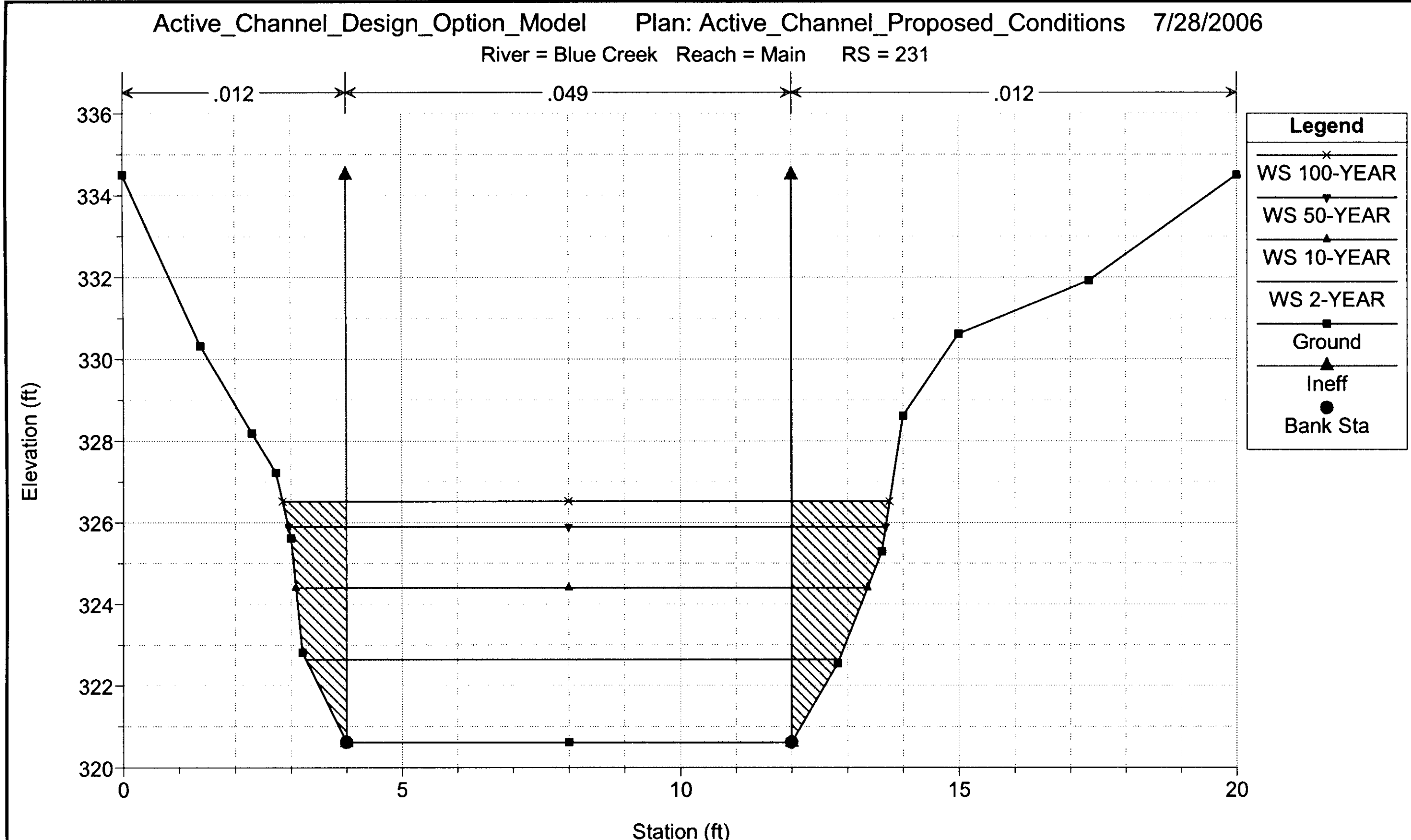

Active_Channel_Design_Option_Model Plan: Active_Channel_Proposed_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 300
.012
.049
.012
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
336
334
332
330
328
326
324
322
320
0
5
10
15
20

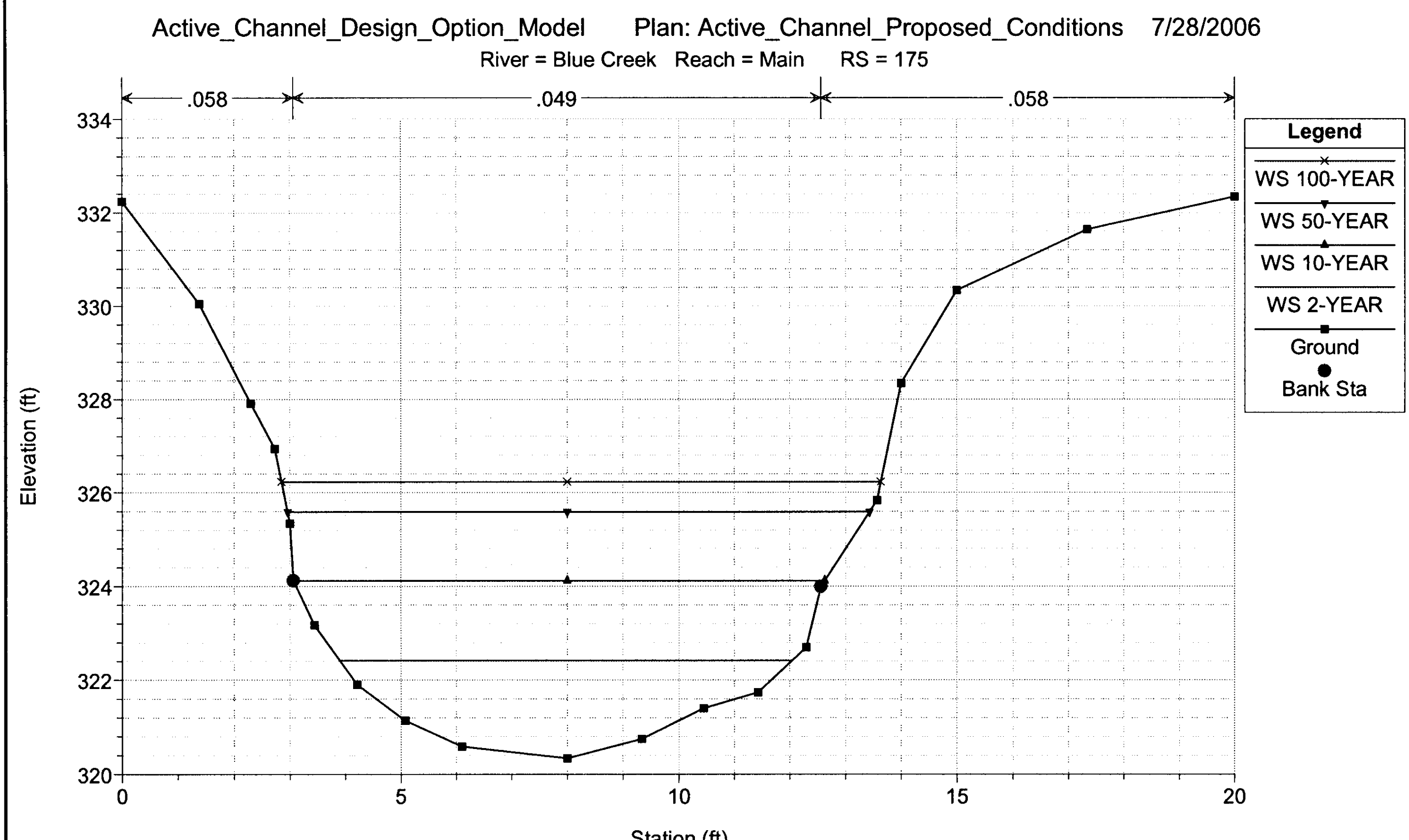


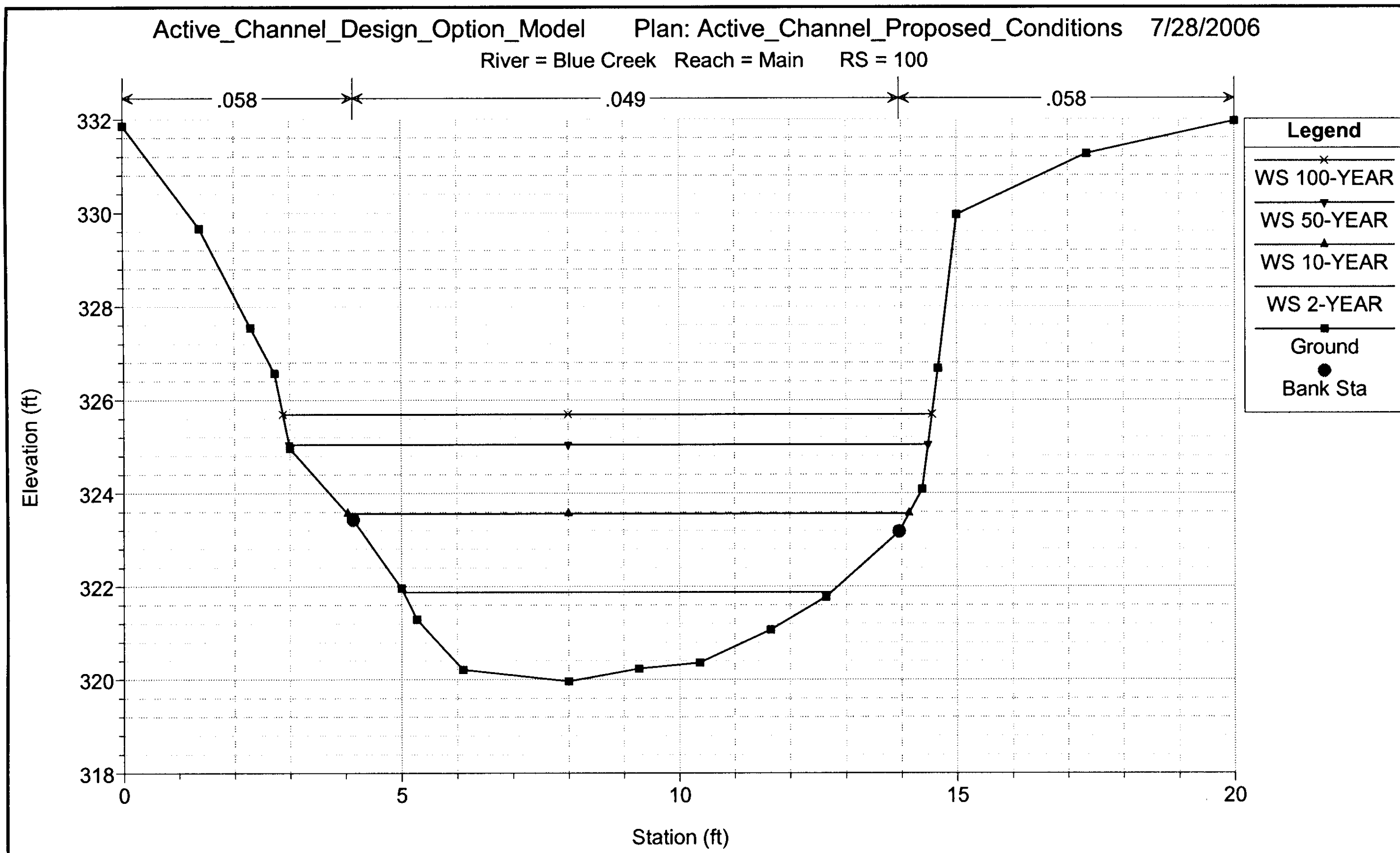
Active_Channel_Design_Option_Model Plan: Active_Channel_Proposed_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 299.5 BR
.012
.049
.012
Legend
WS 50-YEAR
WS 100-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
336
334
332
330
328
326
324
322
320
0
5
10
15
20

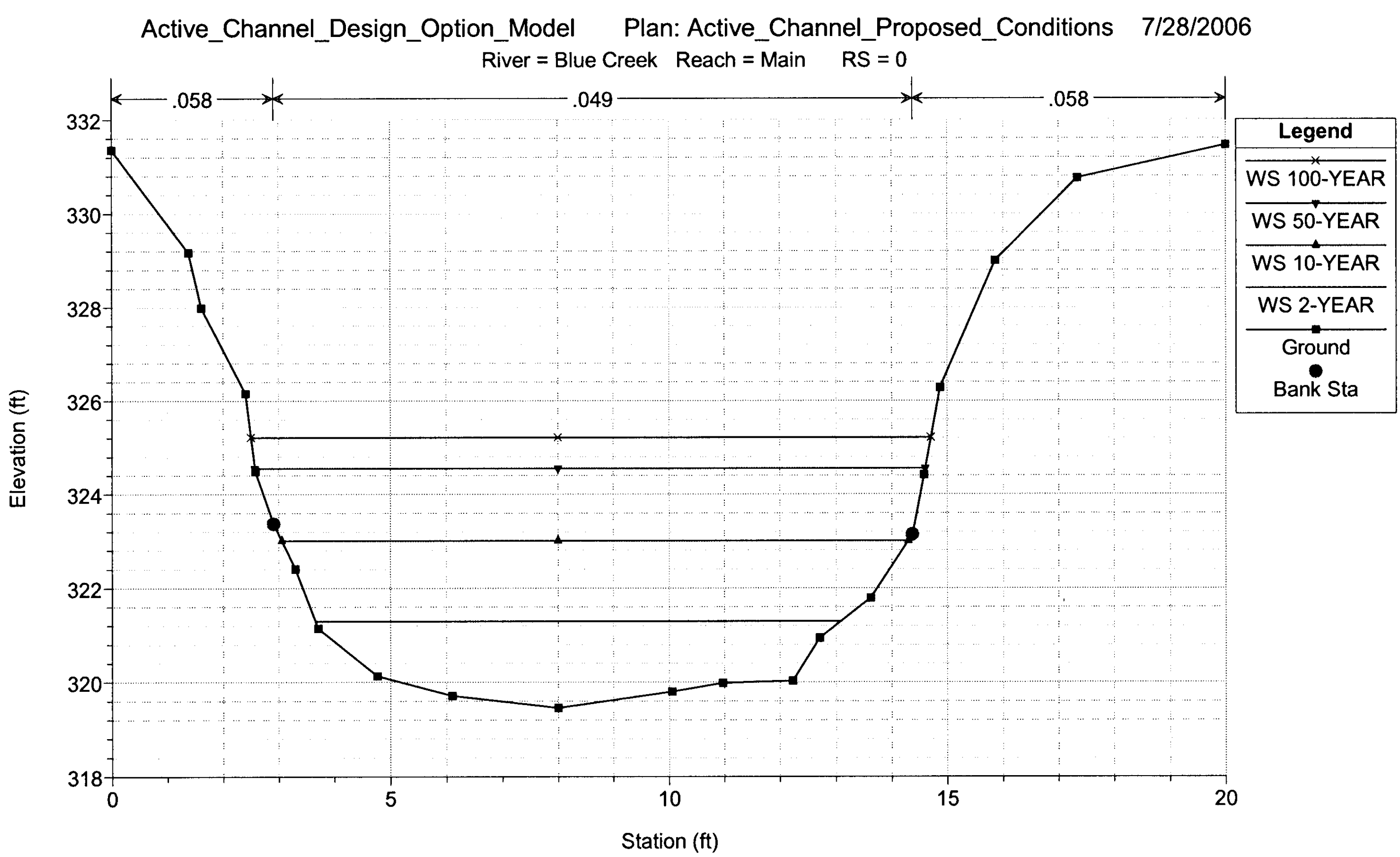


Active_Channel_Design_Option_Model Plan: Active_Channel_Proposed_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 299.5 BR
.012
.049
.012
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
336
334
332
330
328
326
324
322
320
0
5
10
15
20


Active_Channel_Design_Option_Model Plan: Active_Channel_Proposed_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 231
.012
.049
.012
Elevation (ft)
Station (ft)
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Ineff
Bank Sta


Active_Channel_Design_Option_Model Plan: Active_Channel_Proposed_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 175
.058
.049
.058
Elevation (ft)
Station (ft)
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Bank Sta


Active_Channel_Design_Option_Model Plan: Active_Channel_Proposed_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 100
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Bank Sta
Elevation (ft)
332
330
328
326
324
322
320
318
0
5
10
15
20
Station (ft)


Active_Channel_Design_Option_Model Plan: Active_Channel_Proposed_Conditions 7/28/2006
River = Blue Creek Reach = Main RS = 0
.058
.049
.058
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
Ground
Bank Sta
Elevation (ft)
332
330
328
326
324
322
320
318
0
5
10
15
20
Station (ft)

HEC-RAS Plan: Proposed Conditions River: Blue Creek

River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Water Depth (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
0	2-YEAR	30	319.46	321.3	1.84	320.56	321.39	0.00501	2.38	12.59	9.43	0.36
0	10-YEAR	106	319.46	323.01	3.55	321.55	323.2	0.005003	3.48	30.43	11.24	0.37
0	50-YEAR	222	319.46	324.55	5.09	322.55	324.88	0.005004	4.61	48.45	12.03	0.4
0	100-YEAR	284	319.46	325.22	5.76	323	325.62	0.005005	5.09	56.5	12.2	0.41
100	2-YEAR	30	319.96	321.88	1.92		322.01	0.007684	2.89	10.38	7.71	0.44
100	10-YEAR	106	319.96	323.56	3.6		323.83	0.007519	4.17	25.44	10.1	0.46
100	50-YEAR	222	319.96	325.05	5.09		325.52	0.007114	5.5	41.64	11.49	0.48
100	100-YEAR	284	319.96	325.7	5.74		326.26	0.007048	6.04	49.14	11.67	0.49
175	2-YEAR	30	320.34	322.42	2.08		322.53	0.006232	2.68	11.21	8.15	0.4
175	10-YEAR	106	320.34	324.12	3.78		324.37	0.006819	4.01	26.46	9.57	0.42
175	50-YEAR	222	320.34	325.59	5.25		326.05	0.00723	5.47	41.18	10.48	0.47
175	100-YEAR	284	320.34	326.23	5.89		326.8	0.00736	6.06	48.02	10.79	0.48
231	2-YEAR	30	320.62	322.64	2.02	321.38	322.7	0.00146	1.85	16.18	9.6	0.23
231	10-YEAR	106	320.62	324.4	3.78	322.37	324.59	0.002267	3.5	30.25	10.28	0.32
231	50-YEAR	222	320.62	325.9	5.28	323.5	326.33	0.003274	5.26	42.21	10.74	0.4
231	100-YEAR	284	320.62	326.52	5.9	324.02	327.08	0.00369	6.02	47.21	10.91	0.44
299.5		Bridge										
300	2-YEAR	30	320.96	322.76	1.8	321.72	322.83	0.002165	2.09	14.38	9.95	0.27
300	10-YEAR	106	320.96	324.75	3.79	322.72	324.94	0.002256	3.5	30.29	11.52	0.32
300	50-YEAR	222	320.96	327.53	6.57	323.84	327.81	0.001576	4.22	52.56	12.13	0.29
300	100-YEAR	284	320.96	327.94	6.98	324.36	328.34	0.002113	5.09	55.8	12.28	0.34
350	2-YEAR	30	321.21	322.91	1.7		323.03	0.007823	2.75	10.92	9.27	0.45
350	10-YEAR	106	321.21	324.9	3.69		325.09	0.00403	3.42	31.25	11.04	0.35
350	50-YEAR	222	321.21	327.7	6.49		327.9	0.001931	3.67	63.77	12.05	0.27
350	100-YEAR	284	321.21	328.18	6.97		328.46	0.002415	4.33	69.61	12.27	0.3
400	2-YEAR	30	321.46	323.28	1.82		323.4	0.007005	2.7	11.12	8.13	0.41
400	10-YEAR	106	321.46	325.12	3.66		325.34	0.00613	3.78	28.05	10.36	0.4
400	50-YEAR	222	321.46	327.78	6.32		328.03	0.00274	3.97	58.48	12.11	0.3
400	100-YEAR	284	321.46	328.29	6.83		328.62	0.003316	4.63	64.62	12.32	0.34
500	2-YEAR	30	321.96	323.9	1.94		324	0.005119	2.44	12.28	8.42	0.36
500	10-YEAR	106	321.96	325.7	3.74		325.91	0.005163	3.62	29.34	10.58	0.38
500	50-YEAR	222	321.96	328.06	6.1		328.32	0.002993	4.11	56.64	12.05	0.32
500	100-YEAR	284	321.96	328.62	6.66		328.96	0.003472	4.73	63.41	12.23	0.35
600	2-YEAR	30	322.46	324.43	1.97		324.53	0.005521	2.49	12.05	8.03	0.36
600	10-YEAR	106	322.46	326.19	3.73		326.42	0.004873	3.86	28.62	10.27	0.38
600	50-YEAR	222	322.46	328.34	5.88		328.67	0.003632	4.71	51.54	11.08	0.36
600	100-YEAR	284	322.46	328.93	6.47		329.37	0.004133	5.4	58.33	11.77	0.39
800	2-YEAR	30	323.46	325.51	2.05	324.7	325.6	0.005238	2.39	12.58	8.58	0.35
800	10-YEAR	106	323.46	327.18	3.72	325.72	327.41	0.005042	3.85	29	10.71	0.38
800	50-YEAR	222	323.46	329.11	5.65	326.8	329.45	0.004194	4.83	51.15	11.95	0.38
800	100-YEAR	284	323.46	329.79	6.33	327.29	330.22	0.004423	5.4	59.4	12.12	0.4

Plan: Proposed   Blue Creek   Main RS: 299.5   Profile: 2-YEAR

E.G. US. (ft)	322.83	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	322.76	E.G. Elev (ft)	322.82	322.70
Q Total (cfs)	30.00	W.S. Elev (ft)	322.76	322.64
Q Bridge (cfs)	30.00	Crit W.S. (ft)	321.72	321.38
Q Weir (cfs)		Max Chl Dpth (ft)	1.80	2.02
Weir Sta Lft (ft)		Vel Total (ft/s)	2.09	1.85
Weir Sta Rgt (ft)		Flow Area (sq ft)	14.37	16.19
Weir Submerg		Froude # Chl	0.27	0.23
Weir Max Depth (ft)		Specif Force (cu ft)	14.85	18.11
Min El Weir Flow (ft)	334.51	Hydr Depth (ft)	1.80	2.02
Min El Prs (ft)	327.02	W.P. Total (ft)	8.00	8.00
Delta EG (ft)	0.13	Conv. Total (cfs)	644.1	785.6
Delta WS (ft)	0.11	Top Width (ft)	8.00	8.00
BR Open Area (sq ft)	40.76	Frctn Loss (ft)	0.12	0.00
BR Open Vel (ft/s)	2.09	C & E Loss (ft)	0.01	0.00
Coef of Q		Shear Total (lb/sq ft)	0.24	0.18
Br Sel Method	Energy only	Power Total (lb/ft s)	0.51	0.34

Errors Warnings and Notes

Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.
Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.

Plan: Proposed Blue Creek Main RS: 299.5 Profile: 10-YEAR

E.G. US. (ft)	324.94	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	324.75	E.G. Elev (ft)	324.93	324.60
Q Total (cfs)	106.00	W.S. Elev (ft)	324.73	324.40
Q Bridge (cfs)	106.00	Crit W.S. (ft)	322.72	322.37
Q Weir (cfs)		Max Chl Dpth (ft)	3.77	3.78
Weir Sta Lft (ft)		Vel Total (ft/s)	3.61	3.57
Weir Sta Rgt (ft)		Flow Area (sq ft)	29.37	29.73
Weir Submerg		Froude # Chl	0.33	0.32
Weir Max Depth (ft)		Specif Force (cu ft)	68.26	68.64
Min El Weir Flow (ft)	334.51	Hydr Depth (ft)	4.15	4.09
Min El Prs (ft)	327.02	W.P. Total (ft)	13.60	13.26
Delta EG (ft)	0.34	Conv. Total (cfs)	1488.2	1544.3
Delta WS (ft)	0.35	Top Width (ft)	7.08	7.26
BR Open Area (sq ft)	40.76	Frctn Loss (ft)	0.33	0.00
BR Open Vel (ft/s)	3.61	C & E Loss (ft)	0.00	0.00
Coef of Q		Shear Total (lb/sq ft)	0.68	0.66
Br Sel Method	Energy only	Power Total (lb/ft s)	2.47	2.35

Errors Warnings and Notes

Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than
	0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.

Plan: Proposed Blue Creek Main RS: 299.5 Profile: 50-YEAR

E.G. US. (ft)	327.81	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	327.53	E.G. Elev (ft)	327.81	326.33
Q Total (cfs)	222.00	W.S. Elev (ft)	327.02	325.90
Q Bridge (cfs)	222.00	Crit W.S. (ft)	323.81	323.47
Q Weir (cfs)		Max Chl Dpth (ft)	6.06	5.28
Weir Sta Lft (ft)		Vel Total (ft/s)	5.45	5.60
Weir Sta Rgt (ft)		Flow Area (sq ft)	40.76	39.61
Weir Submerg		Froude # Chl	0.39	0.43
Weir Max Depth (ft)		Specif Force (cu ft)	176.98	147.77
Min El Weir Flow (ft)	334.51	Hydr Depth (ft)		7.16
Min El Prs (ft)	327.02	W.P. Total (ft)	22.52	16.79
Delta EG (ft)	1.48	Conv. Total (cfs)	1835.8	2128.7
Delta WS (ft)	1.63	Top Width (ft)		5.53
BR Open Area (sq ft)	40.76	Frctn Loss (ft)		
BR Open Vel (ft/s)	5.45	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)	1.65	1.60
Br Sel Method	Press Only	Power Total (lb/ft s)	9.00	8.98

Errors Warnings and Notes

Note:	The downstream water surface is below the minimum elevation for pressure flow. The sluice
	gate equations were used for pressure flow.
Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.
Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.

Plan: Proposed   Blue Creek   Main RS: 299.5   Profile: 100-YEAR

E.G. US. (ft)	328.34	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	327.94	E.G. Elev (ft)	328.34	327.08
Q Total (cfs)	284.00	W.S. Elev (ft)	327.02	326.52
Q Bridge (cfs)	284.00	Crit W.S. (ft)	324.31	323.98
Q Weir (cfs)		Max Chl Dpth (ft)	6.06	5.90
Weir Sta Lft (ft)		Vel Total (ft/s)	6.97	6.67
Weir Sta Rgt (ft)		Flow Area (sq ft)	40.76	42.55
Weir Submerg		Froude # Chl	0.50	0.48
Weir Max Depth (ft)		Specif Force (cu ft)	200.88	193.72
Min El Weir Flow (ft)	334.51	Hydr Depth (ft)		11.44
Min El Prs (ft)	327.02	W.P. Total (ft)	22.52	19.01
Delta EG (ft)	1.25	Conv. Total (cfs)	1835.8	2208.4
Delta WS (ft)	1.41	Top Width (ft)		3.72
BR Open Area (sq ft)	40.76	Frctn Loss (ft)		
BR Open Vel (ft/s)	6.97	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)	2.70	2.31
Br Sel Method	Press Only	Power Total (lb/ft s)	18.84	15.43

Errors Warnings and Notes

Note:	The downstream water surface is below the minimum elevation for pressure flow. The sluice
	gate equations were used for pressure flow.
Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.
Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.

Summary Statement

The initial goals of this replacement culvert design project included designing a safer roadway, designing a structurally sound culvert, passing the 100-Year storm event, creating a friendly fish passage design for all species, preventing hydraulic design threats downstream, and meeting permissible scour velocities. Specifically for fish passage, all criteria for the Active Channel Design Option were successfully met by following the process laid out within the forms. An overview of the steps include researching existing data and available information, collecting all required parameters at the site, selecting the best fish passage design option for the site, completing the hydrology and efficiently brainstorming and completing the hydraulic modeling, and finally meeting all requirements of the Active Channel Design Option.

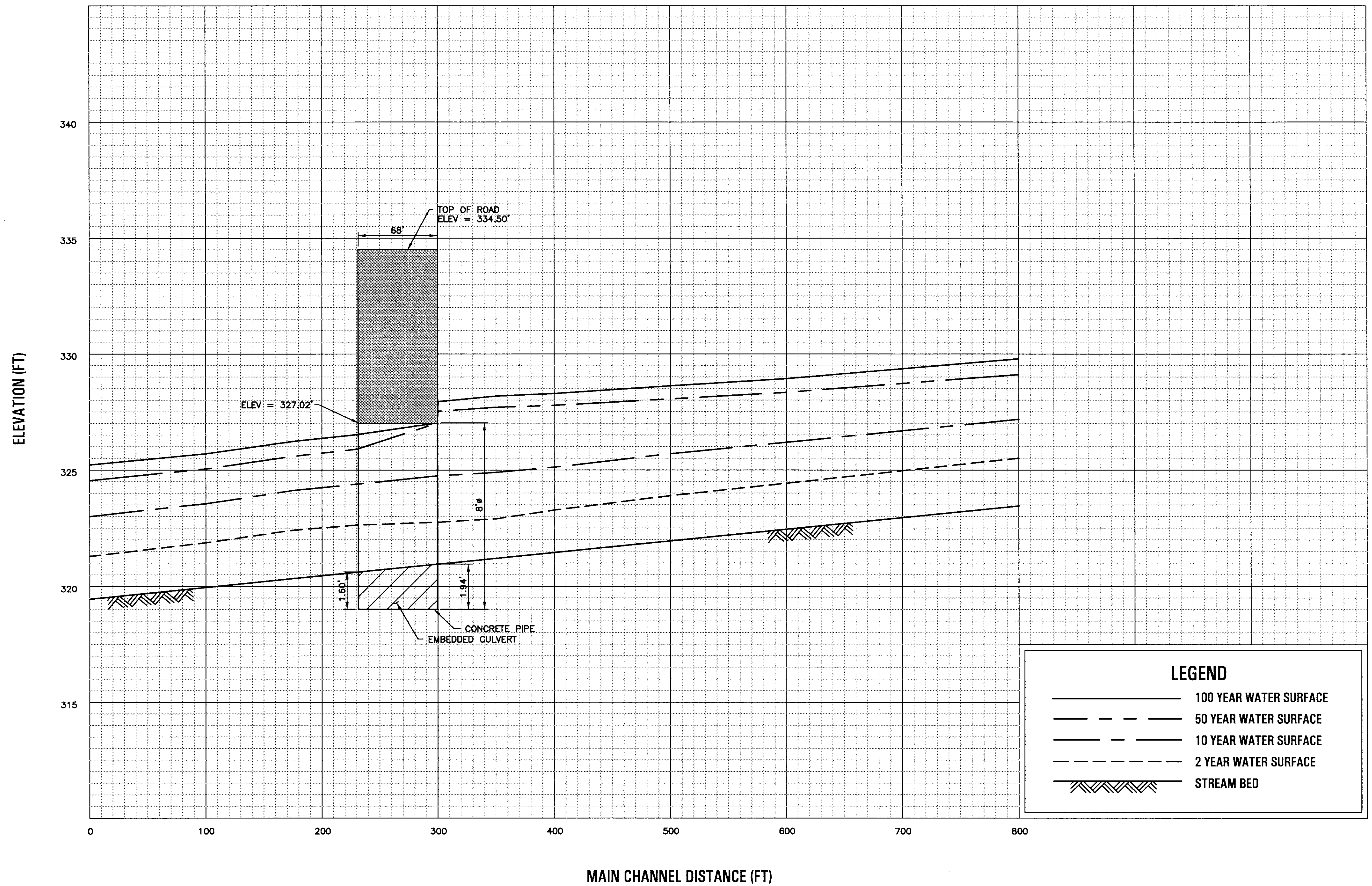
As found in the problem statement, the goal was providing cross drainage for Rose Creek that met hydraulic standards in the Caltrans Hydraulic Design Manual, as well as fish standards in the California Department of Fish and Game Culvert Criteria and the NOAA Fisheries Guidelines for Salmonid Passage at Stream Crossings.

Summary Data Table 1: Culvert Velocities

Geometry Condition and Flood Event	Permissible Velocity for Sustained (2-Year Event) /Intermittent (100-Year Event) Flows in Unlined Channels (ft/s)	Upstream Velocity in Culvert (ft/s)	Downstream Velocity in Culvert (ft/s)
Existing Conditions 2-Year Event / 100-Year Event	5.60 / 6.90	4.63 / 15.25	4.45 / 15.25
Proposed Conditions 2-Year Event / 100-Year Event	5.60 / 6.90	2.09 / 6.97	1.85 / 6.67

Summary Data Table 2: Culvert Depths

<table>
<tr><th>Geometry Condition</th><th>Flood Event</th><th>Water Depth inside Culvert at Inlet (ft)</th><th>Water Depth inside Culvert at Outlet (ft)</th></tr>
<tr><td rowspan="4">Existing Conditions</td><td>50% Annual Probability (2-Year Event)</td><td>2.05</td><td>2.11</td></tr>
<tr><td>10% Annual Probability (10-Year Event)</td><td>4.00</td><td>3.70</td></tr>
<tr><td>2% Annual Probability (50-Year Event)</td><td>4.00</td><td>2.72</td></tr>
<tr><td>1% Annual Probability (100-Year Event)</td><td>4.00</td><td>4.00</td></tr>
<tr><td rowspan="4">Proposed Conditions</td><td>50% Annual Probability (2-Year Event)</td><td>1.80</td><td>2.02</td></tr>
<tr><td>10% Annual Probability (10-Year Event)</td><td>3.77</td><td>3.78</td></tr>
<tr><td>2% Annual Probability (50-Year Event)</td><td>6.06</td><td>5.28</td></tr>
<tr><td>1% Annual Probability (100-Year Event)</td><td>6.06</td><td>5.90</td></tr>
</table>



P:/06938/38713 TD7 Fish Passage/5.0 Project Data/AutoCAD/General Details/Active-Change-blue-creek.DWG
08-03-06 AJACKSON 12:01:30

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

Project Manager: LEF
Designed: EKB
Designed:
Checked: JJL
Drawn: AJ

Route 888 4 Lane
at Blue Creek

ACTIVE CHANNEL DESIGN
PROPOSED CONDITIONS

Date:
Scale: 1" = 100'
Project No.: 06938-38713
File Name: Active-Change-blue-creek.DWG
Drawing No.: 1
Issue: